# Arizona
# Department of Transportation

**WORKBOOK**

for

# INCIDENTAL CONCRETE STRUCTURES INSPECTION (Course Number 202)

a training course developed
for the

**ARIZONA DEPARTMENT OF TRANSPORTATION**
Phoenix, Arizona

by

**ROY JORGENSEN ASSOCIATES, INC.**
Gaithersburg, Maryland

Revised by ADOT – August 29, 2002

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# Directions To Workbook Users

**Incidental Concrete Structures Inspection** (Course 202) is one in a series of courses on inspection and quality control for concrete construction. Other courses in the series include:

- Field Sampling and Testing for Concrete Construction (Course 201),
- Concrete Paving Inspection (Course 203), and
- Major Concrete Structures Inspection (Course 204).

This course is designed primarily for highway construction inspection personnel, but it can also be used in training other personnel.

This workbook is to be used in conjunction with a videotape presentation, discussion sessions with the trainee's instructor, coach, or supervisor, and other materials that make up the course. As sections of this Workbook are assigned, each trainee should:

1. read and study the material to review previously presented information;
2. complete the exercises and quizzes as they are provided;
3. check his answers against those provided following the exercise or quiz;
4. review the material as needed to correct and clarify any incorrect answers; and
5. discuss any areas that are still not clearly understood with his instructor, coach, or supervisor.

Each trainee should be provided with his own copy of this Workbook so that he can write in it and keep it for future reference and review.

This course is based primarily on the following:

- sections from ADOT's *Standard Specifications for Road and Bridge Construction* (commonly referred to as "standard specifications"):
  - 203-5 – Structural Excavation and Backfill,
  - 503 – Concrete Catch Basins,
  - 601 – Concrete Structures,
  - 605 – Steel Reinforcement,
  - 908 – Curb, Gutter, Sidewalks and Driveways,
  - 910 – Concrete Barriers,
  - 912 – Shotcrete,
  - 1003 – Reinforcing Steel,
  - 1006 – Portland Cement Concrete, and
  - 1011 – Joint Materials; and
- B and C Standard Drawings.

# Notes

First Discussion Period
(Introduction and Preparations)

# Section One: Introduction and Preparations

## Introduction

Concrete has a wide variety of uses in highway construction, including:

- various types of incidental concrete structures;
- major structures, such as bridges; and
- roadway pavement.

This course concentrates on the inspection of incidental concrete structures, but many of the basic concepts and methods also are applicable to concrete pavements and major structures.

### Types of Incidental Structures

For purposes of this training, the term "incidental concrete structures" generally refers to all concrete structures except bridges. Incidental concrete structures include such items as:

- curb and gutter,
- sidewalks and driveways,
- retaining walls,
- barrier walls,
- catch basins,
- slope pavement,
- ditch pavement, and
- box culverts.

Although these structures have different functions and characteristics, generally they are similar to each other to the extent that:

- most are relatively small, in comparison to bridges;
- most have relatively limited load-bearing functions, as opposed to the traffic loads borne directly by pavements and bridges;
- some can be precast; and
- they generally involve thc same basic concrete construction methods.

## Contract Documents (Section 105.06)

All concrete construction operations are governed by the following contract documents:

1. **Supplemental Agreements** (Change Orders, Force Accounts and Minor Alterations) provide detailed requirements for a specific project and are the highest authority of the contract documents.
2. **Special Provisions & Addendums** provide additions or revisions to the *Standard Specifications* or project plans on individual projects.
3. **Project Plans** provide detailed drawings, tables, charts, etc., for the project;
4. **Standard Drawings** provide Departmental drawings for repetitive use, showing details to be used where appropriate.
5. **Standard Specifications** provide the most general requirements for all projects.
6. **Approved Concrete Mix Design** which provides details on the mix design as a separate document that is usually required by the Standard Specifications;
7. **Shop Drawings** or **Working Drawings** are drawings, tables, and charts that provide additional construction details not shown in the project plans, but are necessary for completion of the work.

Because of the wide variety in types and designs of concrete structures, the concrete inspector should be thoroughly familiar with all the contract documents as they provide the specific materials requirements, dimensions, and other details that distinguish an individual structure from others. The inspector must use the contract documents extensively by:

- reviewing them thoroughly before the project begins, and
- referring to them frequently throughout all construction operations.

# Basic Concrete Construction

Concrete construction generally can be categorized into four basic overall methods or approaches:

1. fixed-form, cast-in-place concrete;
2. slip-form, cast-in-place concrete;
3. precast concrete; and
4. shotcrete

Of these four approaches, the fixed-form, cast-in-place method is generally the most typical because it can be used for almost any concrete construction. The slip-form and precast approaches are only applicable to certain types of structures. Shotcrete is a special type of pneumatically placed concrete.

Although there are certain differences among these three approaches, all concrete construction involves most of the same basic processes as outlined below:

1. Layout and grade controls,
2. Foundation and subgrade preparations,
3. Reinforcement steel placement,
4. Formwork and falsework erection,
5. Concrete placement
6. Concrete finishing
7. Concrete curing
8. Formwork and falsework removal
9. Backfill placement

## Layout and Grade (Section 925)

Staking for layout and grade control should be done well in advance of the construction operations. Although the Department often may set the initial stakes, it is the Contractor's responsibility to establish any stringlines or other control systems to ensure that the structure is constructed to the correct line and grade. Regardless of who sets the stakes, they must be accurate or the structure will be in the wrong location and may have to be removed and replaced. As an inspector, you should inspect the layout and grade controls in advance, by:

- visit the project site prior to beginning of work to determine that the general layout is in accordance with requirements;
- seeing that they are in the correct location in relation to the construction centerline and station;
- cross-checking the structural stakes in terms of the dimensions, alignment, and grades of the structure in comparison with the plans;
- ensuring that adequate numbers and spacings of offset reference points are provided in accordance with the approved outline which details the method of staking, marking of stakes, grade control, referencing, and structure control;
- seeing that all stakes are clearly identified in terms of the information provided;
- seeing that reference points are firmly set and adequately protected by guard stakes and flagging;
- notifying the contractor or supervisor if any discrepancies are discovered;
- ensure that box culverts are centered on the existing wash and that the skew of the box complements the wash; and
- when possible, be present during surveying and ask questions about staking.

Even after the work begins, monitor the layout and grade controls closely to be sure that the structure is correctly positioned.

## Foundations and Subgrades (Sections 203-5.03 and 601-3.01)

The foundation or subgrade for any structure must be firm and uniform in order to avoid settlement and distribute the load of the structure evenly. As the Contractor prepares the foundation, ensure that:

- the original ground is excavated to the correct grade for the bottom of the structure;
- the excavated area provides adequate safe work space around the structure;
- any special requirements (such as a specific type of bedding or a density requirement) from the specifications and plans are met;
- any unstable earth or rock is removed and replaced with stable backfill that is compacted to the planned grade in lifts of 8 inches or less, or as directed by the Engineer;
- if the contractor over-excavates to below the planned grade, the foundation must be restored with well-compacted backfill to the correct elevation, or as directed by the Engineer; and
- the foundation is maintained free of any water until the concrete is placed and set (unless tremie concrete is to be used).

## Forms and Falsework Erection (Section 601-3.02)

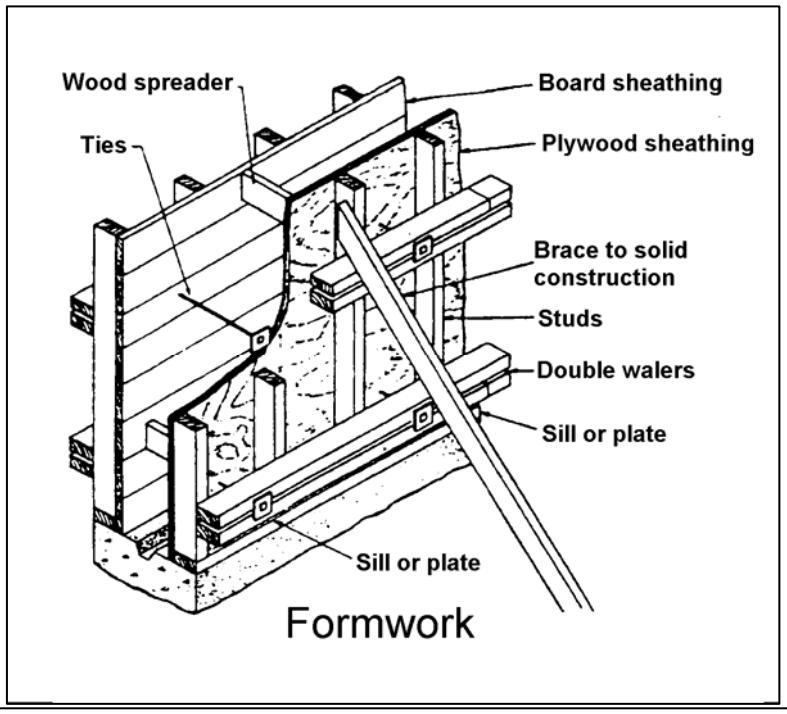
The Contractor is responsible for designing and constructing the forms and falsework for fixed-form concrete work, but they must meet certain requirements. All forms must:

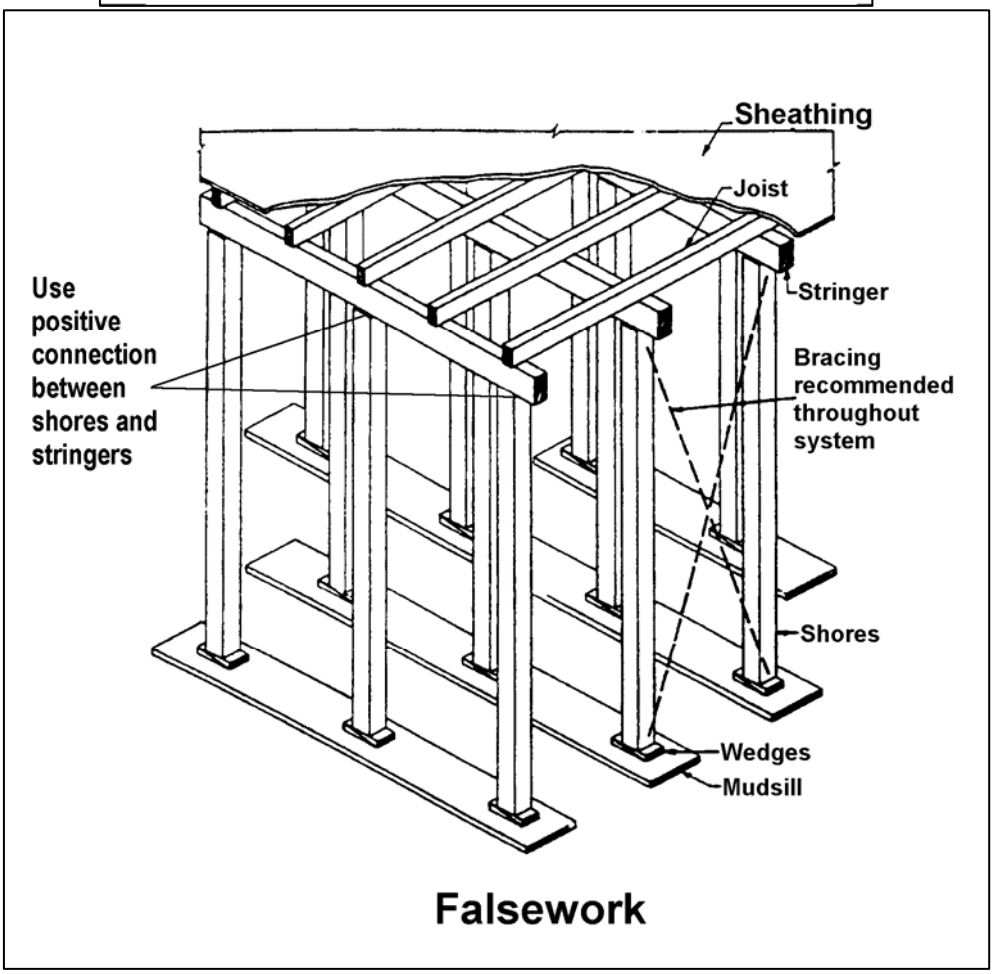
- provide forming faces that are:
  - smooth and uniform,
  - clean of dirt, laitance, oil or any other material that would contaminate or discolor the concrete, and
  - treated with an approved form-release agent, applied before reinforcement is placed;
- be mortar-tight to avoid any leakage (including tape or caulking if needed for surfaces that require a Class II finish);
- be adequately rigid and well supported to hold and retain the concrete without distortion or displacement; and
- be set at the locations, dimensions, lines, and grades as specified on the plans.

If wood forms are used, ensure that:

- plywood is used for the form faces with:
  - the joints and grain generally in line with the line of the structure,
  - no offsets or projections that would leave an impression in the concrete surface, and
  - new plywood (one use only) being used if a Class II finish is required;
- uniform chamfer strips are set at the correct line and grade as required for filletted edges: and
- adequate tie rods, snap-ties, hair-pins, studs, walers, and braces are securely placed as needed for support.

The following illustrations show several of these basic terms and requirements for fixed forms.



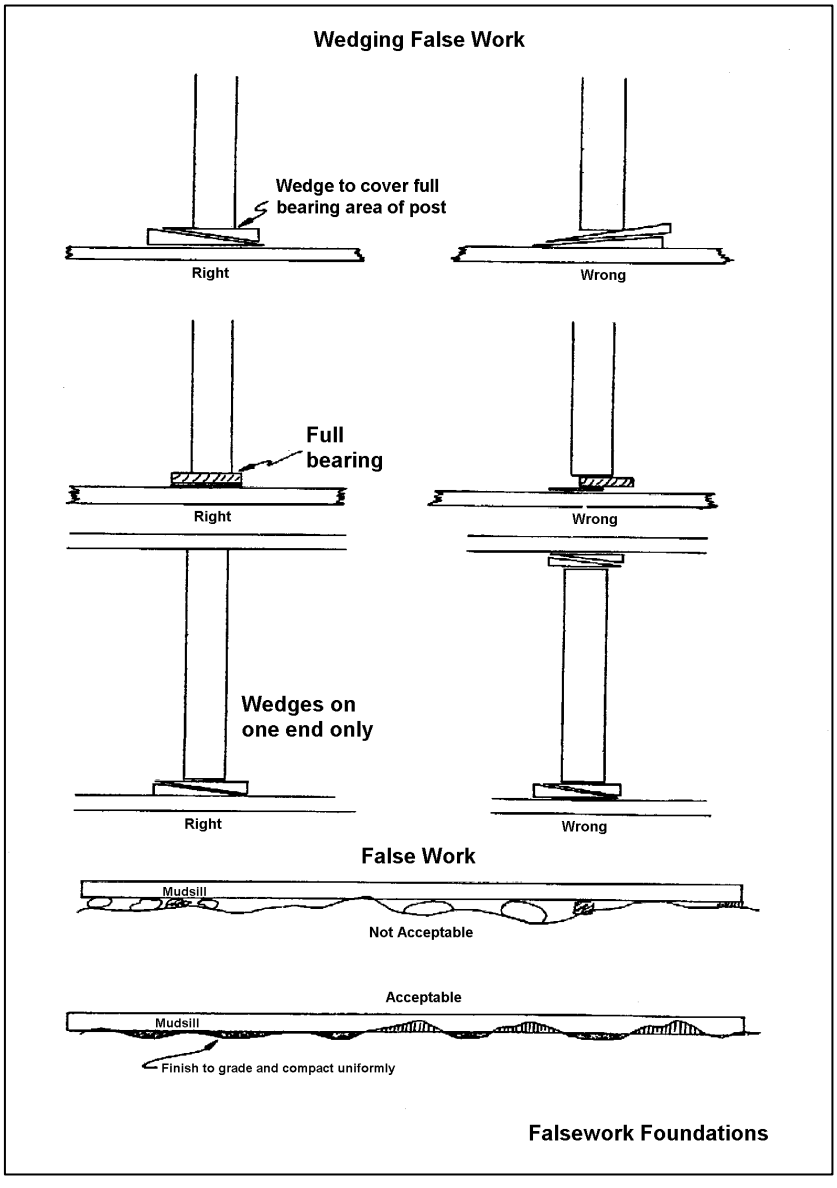



If metal or fiberglass forms are used, the same basic requirements apply, but you should particularly check for:

- any dents or defects that would harm the uniformity of the concrete surface;
- any rust or foreign material that would discolor the concrete surface;
- countersunk bolts and rivetheads; and
- adequate support clamps, rods, and pins.

For the falsework that supports the bottom forms for raised slabs (such as the top slab of a box culvert), ensure that:

- the bottom of the falsework is set on a solid foundation;
- the upper portion provides firm, uniform support;
- such devices as screws, jacks, and wedges are used to hold the forms at the correct elevation; and
- when wedges are used, they are placed in pairs to provide uniform bearing.

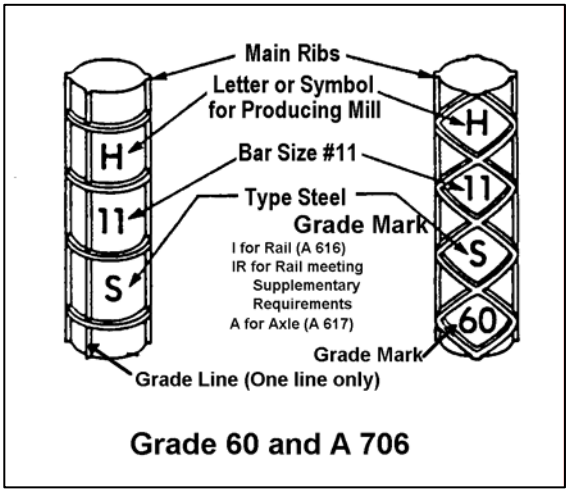



**Falsework Foundations**

## Reinforcement Steel Placement (Section 605 and PPD 92-2)

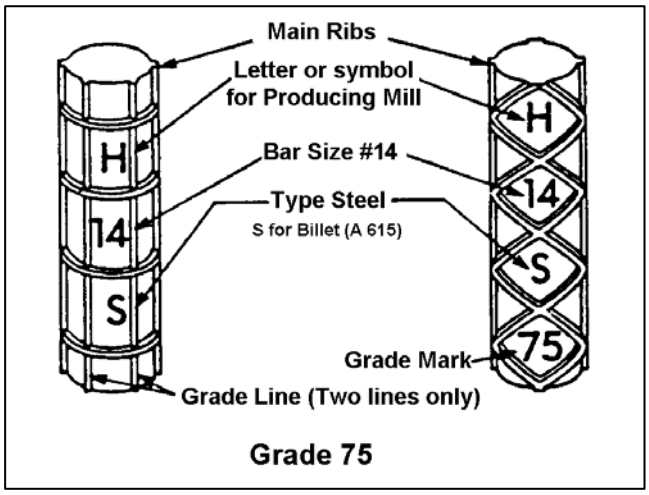
For most structures, some type of reinforcement is required to help improve the overall strength of the structure. Reinforcing materials include:

- uncoated steel bars, which are most commonly used;
- other types, such as welded-wire mesh, epoxy-coated bars, wire spirals and prestressing cable; and
- wire ties and other devices to securely hold the reinforcement in place.



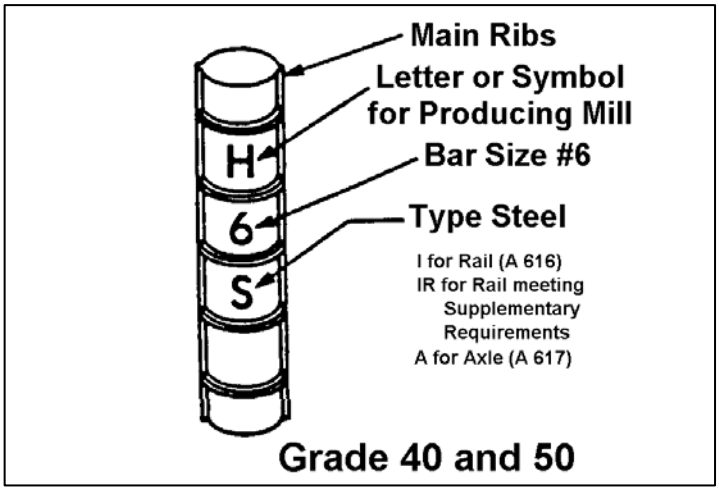

As reinforcing steel is delivered and stored at the project site:

- check its documentation for proper certification and any pretesting or sampling needed;
- check its source, size, type, and grade as illustrated at the right;
- ensure that its sizes, lengths and shapes conform to bar lists and bending diagrams in the plans;
- watch for any loose scale or rust, grease, oil, paint, or other foreign material that could harm the bond with the concrete; and
- make certain that it is properly stored off the ground to avoid water or mud which can cause corrosion.




As the reinforcement is set in place, ensure that:

- all positioning, spacing, sizes, lengths, shapes, and splice locations conform with the plans and/or shop drawings and specified tolerances;



- any field bending is done without heat and any cracked or split bars are not used[1] and cutting the ends of bars for clearance is allowed; and
- all reinforcement is securely supported and held in place:
  - by pre-approved metal chairs, hangers, support wires, or mortar blocks that are as strong as the structure's compressive strength;
  - with such supports having the correct dimensions to provide the required clearances;
  - not by rocks, bricks, wood or metal pipe,
  - by using 16-gauge or heavier wire to secure the reinforcement,
  - with adequate wire ties to hold the steel firmly in place, and
  - without any tack welding (unless approved in writing by the Engineer);
- all clearances (cover) between the forms and the reinforcement are within ¼-inch of those specified on the plans; and
- any splices are located only as shown on the plans[2], using either:
  - lap splicing allowed only for No.11 and smaller bars, or
  - mechanical-connection splicing.

## Wire and Rebar Measurement Conventions

Wire gauge numbers are smaller for heavier wire, such that 15-gauge wire is heavier that 16-gauge while 17-gauge is lighter.

In English units, the rebar size is indicated by the number stamped on the side, as shown in the illustration on page 9. The bar size number indicates how many eighths of an inch in diameter the rebar is. For example, if the number is 8, the rebar is 8/8", or 1" in diameter. A rebar stamped with the number 4 is 4/8", or ½" in diameter.

Standard sizes and weights for rebar appear in the table below.

| Diameter Size | Stamped Mark | Area in Square Inches | Weight in lbs. per foot |
|---|---|---|---|
| ⅜" | #3 | 0.11 | 0.376 |
| ½" | #4 | 0.20 | 0.668 |
| ⅝" | #5 | 0.31 | 1.043 |

In choosing the size designation, the maximum size of coarse aggregate shall not be larger than one-fifth of the narrowest dimension between sides of adjacent forms, or two-thirds of the minimum clear spacing between reinforcing bars, or one-third the depth of the slab, whichever is least.

[1] See the *Standard Specifications*, Section 605-3.01, page 513 for more requirements on bending rebar..
[2] The type and method of splices and connections not shown on plans shall be approved by the Engineer.

# Section One Quiz

1. Which of the following overall concrete construction methods is generally the most typical for incidental structures? (Circle one)

   a. slip-form, cast-in-place
   b. fixed-form, cast-in-place
   c. precast

2. Which of the following contract documents provides the most specific information on the location, materials and dimensions of an individual structure? (Circle one)

   a. Standard Provisions
   b. Special Provisions
   c. Supplemental Specifications
   d. Contract Plans

3. Which of the following basic processes in concrete construction are **not** applicable to slip-form concrete work? (Circle one or more)

   a. setting forms
   b. curing the concrete
   c. backfilling
   d. layout and grade controls

4. If a reference point appears to be out of line when checking alignment and grade controls, the inspector should … (Circle one or more)

   a. make sure that there is another reference point that can be used and remove it to avoid confusion.
   b. have the contractor replace it to a new alignment.
   c. notify the contractor.
   d. determine its proper location from the plans and relocate it.

5. If the foundation material is unstable at the planned grade for the bottom of a structure, which of the following actions should be taken? (Circle one)

   a. Relocate the structure to a higher, more stable grade by adding an 8-inch layer of stable backfill.
   b. Remove the unstable material and replace it with layered and compacted backfill.
   c. Stop all work and contact the Structures Division.

6. Which of the following is **not** a requirement for form faces in fixed-form construction? (Circle one or more)

   a. They must be mortar-tight.
   b. Any plywood must be new if a Class II finish is required.
   c. They must be reusable.
   d. Any bolt or rivet heads must be countersunk.
   e. They must be waterproof.
   f. They must be sufficiently flexible to yield without breaking under pressure from the concrete.

7. Which of the following should **not** be permitted in placing reinforcing steel? (Circle one or more)

   a. using 15-gauge wire ties at bar intersections
   b. using a welding torch to facilitate bar bending
   c. tack welding re-bars to metal support chairs
   d. a clearance between reinforcement and the form face that is ⅛-inch more than shown on the plans
   e. lap-splicing number-14 re-bars
   f. using wooden blocks as spacers and supports

# Section One Quiz Answers

1. b. fixed-form, cast-in-place

2. d. Contract Plans

3. a. setting forms

4. c. notify the contractor

5. b Remove the unstable material and replace it with layered and compacted backfill.

6. c. They must be reusable.
   e. They must be waterproof.
   f. They must be sufficiently flexible to yield without breaking under pressure from the concrete.

7. b. using a welding torch to facilitate bar bending
   c. tack-welding re-bars to metal support chairs
   e. lap-splicing number-14 re-bars
   using wooden blocks as spacers and supports

# Notes

Second Discussion Period
(Concrete Placement)

# Section Two: Concrete Placement

This section summarizes the key points in inspecting concrete placement operations for fixed-form and precast concrete. Emphasis is placed on the fixed-form method, followed by highlighting the key similarities and differences for the other two methods.

Shotcrete is also briefly discussed at the end of the section.

## Fixed-Form Concrete

The fixed-form, cast-in-place method can be used for just about any incidental concrete structure. Its basic requirements for weather, pre-placement, discharge, consolidation, and finishing are also fundamental to other methods with only certain variations.

### Weather and Temperature Limits (Section 1006-5)

The two basic weather and temperature requirements for placing concrete are:

1. Concrete may <u>not</u> be placed when rain is hard enough to:
   a. cause a muddy foundation, or
   b. wash or flow the concrete;

2. The temperature of the concrete must be within 50° and 90° F throughout placement.

In hot weather, ensure that:

- the 90° F concrete temperature limit is met by such methods as pre-cooling the component materials as needed at the plant; and
- the foundation, forms and reinforcement are sprinkled with cool water just before the concrete is placed.

In cold weather, ensure that:

- no concrete is placed against any frozen or ice-coated foundation, forms or reinforcement;
- concrete placement is stopped if the descending air temperature in the shade falls below 40° F and resumed only after ascending temperature is raised above 35° F (unless otherwise approved by the Engineer, with appropriate precautions as outlined below);
- the temperature of the concrete is maintained and controlled for seven days at:
  - 50° F or higher for the first 3 days (72 hours), and
  - 40° F or higher for the remaining 4 days (96 hours);

- the previously mentioned concrete temperatures are maintained in a manner approved by the Engineer, including:
  - pre-heating the aggregates water or both at the plant, and/or
  - protecting the in-place concrete with insulation, artificial heat or both; and
  - on-hand before any concrete is placed, gradually removed after a seven-day curing period, and
- any equipment or material needed to maintain the in-place concrete temperature.

## Pre-Placement Checks (Section 601-3.03(4))

A thorough inspection of the forms and reinforcement takes time. Check them carefully, well before the concrete is even ordered. Do not wait until just before the pour. Even before the Contractor orders any concrete for delivery and placement at the site, you should:

- thoroughly inspect the foundation, forms and reinforcement for the proper dimensions, layout, grade, support, and other requirements;
- ensure that any necessary corrections to the foundation forms or reinforcement are made; and
- make sure that the Contractor has the necessary labor, tools, and equipment on hand to place, consolidate, finish, and cure the concrete properly.

As concrete is delivered to the site but before it is discharged:

- ensure proper mix design is utilized;
- ensure that the foundation, forms, and adjacent concrete surfaces are wet down with water; and
- check the batch time on the Delivery Ticket to ensure compliance with discharge time limits:
  - 90 minutes for mixer or agitator trucks, or
  - 45 minutes for non-agitating trucks, and
  - concrete hauled in open-top vehicles shall be protected against access to rain, or exposure to the sun for more than 30 minutes when the ambient temperature exceeds 85° F.

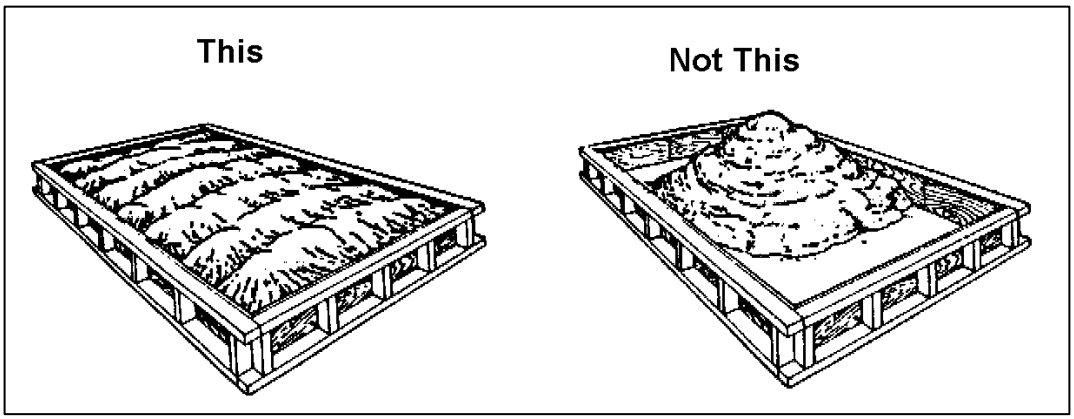
## Discharging Concrete (Section 601-3.03(A))

As concrete is discharged from the truck and placed in the forms, ensure that it is fully and uniformly mixed and free of any contamination or partially hardened mix.

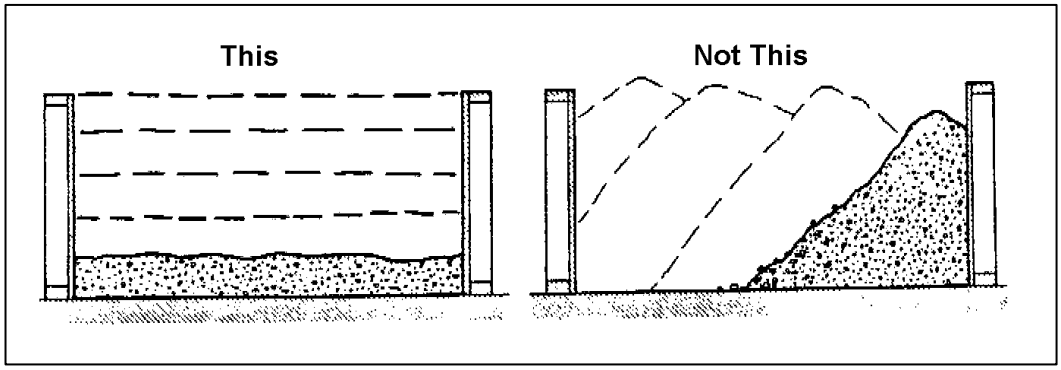
Concrete shall be placed as nearly as possible in its final position and the use of vibrators for shifting the mass of fresh concrete will not be permitted. Dropping the concrete more than eight feet without the use of approved pipes or tubes will not be allowed.

For placement in dry excavations, concrete may be placed by free-fall except in cohesionless soils or where other caving conditions exist. The contractor shall prevent concrete from striking either the reinforcing cage or excavation side walls during free-fall. Where free-fall cannot be used, concrete shall be placed through a suitable clean downpipe.[3]

- placed as near as possible to its final position (as illustrated below at left) – not in a large pile that must be distributed into place (as illustrated below at right);




- placed in uniform layers no more than 24 inches deep (as shown below at left) – not piled at the end of the form (as shown below at right);




- placed and consolidated without shifting or displacing the reinforcement or forms;
- layered at a rate that will not create "cold joints," in which the preceding layer is partially set when the next layer is placed;
- not pushed or shifted into position by dragging vibrators; and
- generally discharged and placed in a manner that will not cause segregation of the mix.

**NOTE:** Where appearance is important, placement of the vibrator should be closer to the edge of the form. This will eliminate horizontal lines.

[3] See the *Standard Specifications*, Section 609-3.07 (B) on page 548.

## Pumping Concrete (Section 601-303(C))

Pumping is often used to convey the mix to the forms. When pumping is used, you should specifically ensure that:

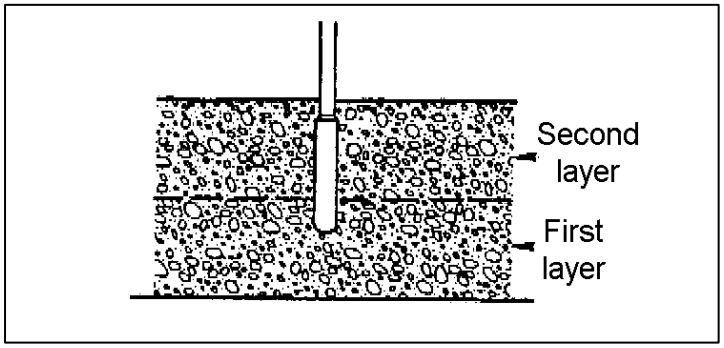
- the pumping equipment will satisfy the intended placing rate and other job requirements;
- the stand-by pumping equipment is readily available, and the used equipment is flushed after each use;
- aluminum alloy pipelines are not used in the delivery of concrete;
- the grout mix material used to prime the pump is not placed in the structure;
- the pump provides a continuous stream of mix, without air pockets voids or segregation;
- a well proportioned concrete mix is utilized in the pumping operation; and
- sampling and testing of the concrete mix is conducted in accordance with subsection 1006-4.04, fourth paragraph of the *Standard Specifications*.

For information purposes a copy of a reference article entitled "Placing Concrete by Pumping Methods," ACI 304.2R may be obtained from Materials Testing Section.

## Consolidation (Section 601-03.03(D))

Concrete must be consolidated to remove entrapped air voids that can occur in corners, along form faces, around reinforcement, or elsewhere in the mix. To ensure that the concrete is properly consolidated, make sure that:

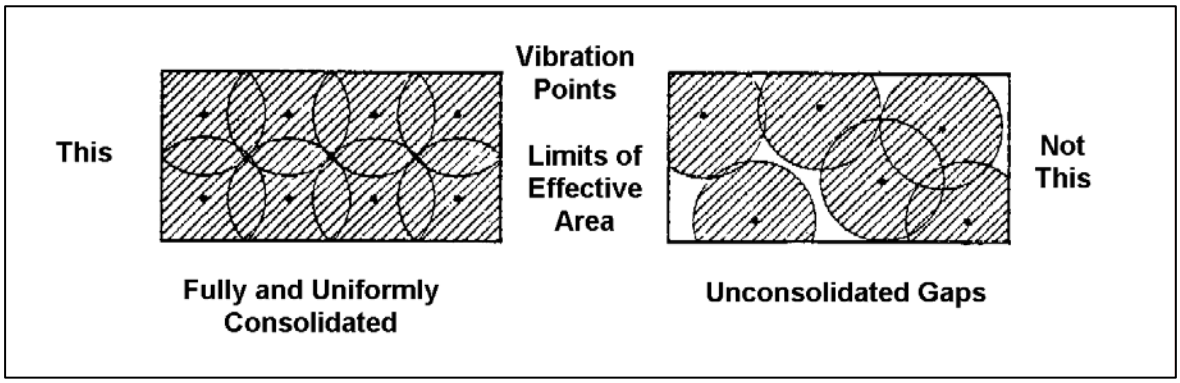
- only approved vibrators with a minimum frequency of 8,000 cycles per minute are used[4];
- vibrators are operated properly by:
  - lowering them into the concrete through the full depth of each layer,
  - penetrating at least 6 inches into the previous layer on multi-layer pours (as shown below);




  - avoiding direct contact with form faces and reinforcement;

[4] Relatively flat structures like curb and gutter, sidewalk and driveways may be consolidated by spading the mix into the forms or using a tamping device.

- holding the vibrator in one place briefly until the concrete stops sealing (to avoid over-vibrating which segregates the larger aggregates to the bottom);
- removing the vibrator slowly and without dragging it across the surface; and
- repeating the process with uniform spacing between vibration points so that the effective areas the vibration points overlap for full coverage (as shown below at left) – not with wide spacing that leaves gaps of unconsolidated areas (as shown at right below); and




- consolidation is completed within 15 minutes after the concrete has been placed.

## Finishing Unformed Surfaces (Section 601.3.05)

The exposed top surface of a structure must be finished after placement and consolidation are completed. As the exposed surface is finished, ensure that:

- the surface is struck-off:
  - at the planned line and grade,
  - flush with any adjacent structures, and
  - using a strike-board roller screed[5] or another type of screed for flat slabs or sloped surfaces;
- a smooth, uniform surface is achieved with such tools as:
  - wood floats for initial finishing, and
  - metal trowels and bull floats to smooth and seal the surface;
- edge-finishing is completed as specified (usually ¼-inch radius edges);
- any special finishing requirements are met, such as:
  - straightedging tolerances (¼-inch per 10 ft. for curb, gutter, sidewalks and barrier walls),
  - final fine brush finish (for curb, gutter, sidewalks and driveways), and
  - exposed-aggregate finish (as often specified for slope pavement); and
- curing is started immediately after the exposed surface has been finished.

[5] Roller screeds also provide some consolidation action. So they are often used in such structures as slope and ditch pavement where the use of vibrators can tend to encourage the mix to flow down the slope.

# Slip-Form Concrete

Such incidental structures as curb, gutter, sidewalks and barrier walls may be constructed by slip-form placement methods.

Preparations for slip-form placement are generally similar to those for fixed-form placement, but:

- check the slip-form machine
- check the reinforcement, if applicable; and
- special consideration should be given to the alignment and grade controls including:
  - making sure that the slip-form equipment has automatic alignment and grade controls, and
  - checking the Contractor's stringline or wire reference closely.

The weather and temperature limits for slip-form are the same as for fixed-form operations.

The key points in inspecting the placement, consolidation and finishing of concrete in slip-form operations are:

- closely monitoring the slump of the mix;
- observing the rates of:
  - the feed of concrete into the slip-form equipment, and
  - travel of the equipment;
- watching for honeycombing, excessive grout, or other indications of inadequate or excessive consolidation;
- watching for other deficiencies such as pulling, tearing, or excessive edge slump; and
- generally seeing that the results equal or exceed those of fixed-form placement.

# Precast Concrete
# (Sections Cattle Guards, Headwalls, Median Barriers, and Catch Basins 910, Precast Concrete 601-4.02(B), 203-5.03(B)(3), 503-3.01 910-3.04, and 601-1)

Catch basins, barrier walls, and retaining walls may be constructed in precast units or sections. Staking and foundation preparations are similar to those for cast-in-place concrete, but the processes of forming, reinforcing, placing, and consolidating concrete, finishing and curing are usually carried out at the fabrication plant rather than the construction site.

As precast concrete items are delivered to the construction site:

- make sure that a Certificate of Compliance has been submitted and that the precast item is stamped to indicate that it has been approved for use[6] or is on the Approved Products List in the Special Provisions;
- ensure that they are transported and stored properly:
  - in an upright position,
  - with support at the final bearing points; and
- inspect them closely for such defects as:
  - deviations from plan dimensions,
  - exposed reinforcement,
  - honeycombing, or
  - cracks.

Before precast units are set in place, special consideration must be given to their foundations, including:

- a structural backfill bedding – for catch basins or similar precast items – that must be:
  - at least 6 inches deep,
  - compacted to at least 100 percent of the maximum lab density of the material, and
  - at or near optimum moisture at the time the precast unit is placed,
  - shaped to fit the bottom of the precast unit, and
  - trimmed or filled in as needed to provide full uniform support of the structure;
- a special grout bedding – for precast sections of barrier wall – that must:
  - be at least one inch deep, and
  - extend from under the section as it is set in place; or
- a cast-in-place concrete footing – as commonly used for retaining walls – including any shims or bearing pads that may be required.

Other key points to watch for in the installation of precast concrete units are:

- proper handling by means of special lifting holes, loops, or devices to minimize uneven stress that could damage the item;
- correct alignment and grade of the precast unit as it is set in place;
- provided with adequate temporary support, as needed (particularly for precast retaining wall panels) until other construction operations can be completed;
- properly constructed joints between precast sections, including:
  - mortared construction joints between catch basin sections, and
  - doweled, sealed and pressure-grouted joints between barrier wall sections; and

[6] The precast item should have an ADOT stamp. However, some items within a lot may not have the ADOT stamp. If there is no ADOT stamp, it should at least have a date stamp which can be used to verify its pre-approval with the central materials lab.

- removal and finishing of lifting devices, including:
  - filling and finishing lifting holes with mortar, and
  - removing lifting loops below the surface, filling the recesses with mortar and finishing the surface.

## Shotcrete (Section 912)

Shotcrete is a special type of concrete (or mortar) that is applied under pressure through a hose. It is commonly used for sloped surfaces in ditch pavement or sloped surfaces under bridges.

The specifications allow for both:

- dry-mix shotcrete (for mortar only), in which water is added at the hose nozzle; and
- wet-mix shotcrete, in which additional air is added at the hose nozzle.

The key points for inspecting shotcrete operations are:

- the foundation must be:
  - finely graded to the planned lines and grade,
  - thoroughly compacted, and
  - uniformly moistened;
- forms must be:
  - able to resist deflection from the pressurized placement, and
  - designed to allow air and rebound to escape;
- reinforcement is usually welded-wire mesh and must be securely positioned and supported to resist movement under pressure;
- ground or gauging wires must be installed, where necessary, to control the thickness and grade of shotcrete;
- shotcrete may <u>not</u> be placed when:
  - rain would wash the shotcrete,
  - wind would separate the flow of materials as they spray out of the nozzle, or
  - the air temperature (in the shade) falls below 40° F
- shotcrete must be properly applied by:
  - maintaining an approved uniform rate,
  - keeping the nozzle perpendicular to and 2-5 ft. from the surface,
  - minimizing and removing any rebound, and
  - leave a natural gun (nozzle) finish (unless otherwise specified); and
- curing must last at least seven days by:
  - continuous water spray or fog,
  - curing compound, or
  - polyethylene plastic sheeting.

# Section Two Quiz

1. Which of the following weather and temperature conditions would prevent placement of cast-in-place concrete, assuming that no exceptions have been otherwise approved by the Engineer? (Circle one or more)

   a. an air temperature (in the shade) of 103° F
   b. a partially frozen foundation
   c. a concrete temperature of 92° F
   d. a concrete temperature of 37° F and rising

2. Foundations, forms and reinforcement should be thoroughly inspected for conformity with all requirements ... (Circle one or more)

   a. ... as they are prepared.
   b. … before any concrete is delivered to the pour site.
   c. … after concrete is delivered, but before it is discharged.
   d. … as concrete is being discharged.

3. In placing concrete in forms, which of the following practices should **not** be allowed? (Circle one or more)
   a. using tubes or pipes to carry the concrete
   b. placing it in 15-inch layers
   c. leaving enough time between layers to create a "cold joint"
   d. piling it in the middle of the forms for distribution to other areas as it is consolidated

4. Which of the following types of structures may be constructed in precast concrete sections? (Circle one or more)

   a. curb and gutter
   b. ditch pavement
   c. barrier walls
   d. sidewalk
   e. catch basins

5. Which of the following practices should **not** be allowed in consolidating concrete with a vibrator? (Circle one or more)

   a. dragging it across the surface from one vibration point to the next
   b. overlapping the effective areas of the vibration points
   c. penetrating 8 to 10 inches into a previous layer
   d. holding the vibrator for about one minute at each location

6. Which of the following finishing operations is required for the exposed surfaces of curb, gutter and sidewalk, but generally **not** for most other incidental structures? (Circle one or more)

   a. strike-off to planned grade
   b. smoothing with floats or trowels
   c. final fine brush finish
   d. straightedge tolerance checks
   e. edge finishing

7. Which of the following are key considerations in the inspection of slip-form concrete operations, but are **not** applicable to fixed-form operations? (Circle one more)

   a. the provision of automatic alignment and grade controls
   b. proper consolidation of the concrete
   c. different weather and temperature limitations
   d. watching for deficiencies such as pulling, tearing, and edge slump

8. Which of the following processes used in fixed-form, cast-in-place concrete is **not** applicable to shotcrete? (Circle one or more)

   a. alignment and grade controls
   b. finishing exposed surfaces with floats and trowels
   c. consolidating with vibrators
   d. setting forms
   e. placing reinforcement

# Section Two Quiz Answers

1. b. a partially frozen foundation
   c. a concrete temperature of 92° F
   d. a concrete temperature of 37° F and rising

2. a. ... as they are prepared.
   b. ... before any concrete is delivered to the pour site.

3. c. leaving enough time between layers to create a “cold joint”
   d. piling it in the middle of the forms for distribution to other areas as it is consolidated.

4. c. barrier walls
   e. catch basins

5. a. dragging it across the surface from one vibration point to the next
   d. holding the vibrator for about one minute at each location

6. c. final fine brush finish
   d. straightedge tolerance checks

7. a. the provision of automatic alignment and grade controls
   d. watching for deficiencies such as pulling, tearing, and edge slump

8. b. finishing unformed surfaces with floats and trowels
   c. consolidating with vibrators

# Notes

Third Discussion Period
(Completing Concrete Construction)

# Section Three: Completing Concrete Construction

Even after concrete is placed, there are still several other processes to be completed. These include:

- constructing joints,[7]
- curing,
- formwork and falsework removal,
- concrete finishing, and
- backfill placement.

## Concrete Joints (Section 601-3.04)

The three basic types of concrete joints – (1) construction joints, (2) expansion joints, and (3) weakened-plane joints – are each discussed below.

### Construction Joints

Construction joints are placed between separate pours within a structure to hold the separate pours rigidly together. When inspecting construction joints, ensure that:

- they are constructed only at the locations shown in the plans, also shown on the Standard Drawings or approved by the Resident Engineer;
- the previous pour is complete:
  - at the correct grade,
  - with a rough unfinished surface,
  - with properly formed keyways when a keyed joint is required, and
  - with extension of the reinforcement or tie bars into the next pour;
- preparations are made for the next pour by:
  - drawing the forms tight,
  - removing any temporary keys,
  - cleaning the existing surface, reinforcement and forms free of any laitance or other foreign material, by:
    - air or water jets, if less than 8 hours after previous pour, or
    - abrasive blast cleaning, if more than 8 hours,
  - saturating the surface with water; and
- the subsequent pour is properly placed and consolidated.

[7] Although certain aspects of joint construction actually take place before or during concrete placement, joint construction is covered here for organizing purposes.

## Expansion Joints (Sections 601-3.04(A), 908-3 and 1011)

Expansion joints use compressible material to allow concrete to expand without breaking. Expansion joints are typically located:

- between adjacent concrete structures;
- at specified intervals within linear structures such as curb and gutter, sidewalk, barrier walls, and ditch pavement; and
- other locations, such as between the headwall and wingwalls of a concrete headwall.

As expansion joints are constructed, ensure that:

- they conform with the plans in terms of the locations, dimensions, and type of joint material used;
- joint material is placed to the full depth and length of the joint;
- joint edges are cleaned and edge-finished in accordance with the plans; and
- the joints are properly sealed with the correct type of material and to the correct depth, when required by the plans.

## Weakened-Plane Joints (Section 908-3)

Weakened-plane joints are placed at intervals within linear structures to control cracking as the concrete hardens, by encouraging it to crack only at the joints. Depending on the type of structure, weakened-plane joints may be:

- formed in fresh concrete by:
  - parting the large aggregates to a depth of two inches, and
  - finishing the joint with a jointer tool; or
- sawed in the concrete after its set and partially cured.

All weakened-plane joints must conform with the locations, depths and widths shown on the plans.

# Concrete Curing (Section 1006-6)

The hardening of concrete must be properly cured to control cracking, shrinkage and warpage. Ensure that all concrete is cured:

- for the specified period of time:
  - at least 7 days for type II, or
  - at least 3 days when a Type III, rapid-curing (high early strength) cement is used; and

- by using one or more of the following methods:
  - forms-in-place, for formed surfaces,
  - liquid membrane-forming curing compound for exposed surfaces,
  - water curing for exposed surfaces (which is permissible but rarely used except for bridge decks where it is required), or
  - a combination of the above.

For most incidental concrete structures, inspect the curing operations by seeing that:

- all form joints for forms-in-place curing are moisture tight;
- curing compound (or water curing) is applied uniformly to surfaces immediately after surface finishing is completed and any water sheen is gone;
- curing compound is applied at a rate of at least:
  - one gallon per 150 square feet for curb, sidewalks and driveways, or
  - one gallon per 100 square feet for other structures;
- any breaks in the curing compound film are closed with an application of at least 1 gallon per 200 square feet;
- any formed surfaces that are exposed by removing forms before the full curing period is complete are cured by the curing compound (or water) method for the balance of the curing period;
- curing compound is not applied to surfaces requiring a Class II finish until after the finishing is completed[8];
- no traffic, equipment, or stored materials are allowed on the structure until it is fully cured as in box-girder bridges; and
- document the curing methods used, times applied, areas of surfaces, and quantities of curing compound used (clear pink for Type 1-D, and white for Type 2).

## Formwork and Falsework Removal (Section 601-3.02(D))

The basic requirements for the removal of any forms and falsework are that:

- no forms or falsework may be removed until authorized by the Engineer (or the inspector, as the Engineer's representative);
- all forms and falsework eventually must be removed unless there is no permanent access; and
- all forms and falsework must be removed in a manner that will not damage the structure.

[8] Finishing is required to be completed immediately after removal of forms. See the *Standard Specifications*, Section 601(A) on page 471.

Timing is a key consideration in the removal of forms and falsework. In terms of curing the concrete, forms and falsework must remain until the concrete is sufficiently set or hardened to support itself. But for finishing purposes, it is generally better to remove the forms as early as possible to finish the surface while it is still green. So the timing of falsework and forms removal depends largely on the type of structure as well as its curing and finishing.

For example:

- the curb-face form in fixed-form curb and gutter usually needs to be removed after an hour or two, in order to finish the surface and construct joints;
- the side forms for other relatively horizontal structures (sidewalks and driveways) might be removed later the same day; and
- the side forms for larger or more vertical structures can often be stripped the next day — IF:
  - the formed-surface finishing is started immediately after forms removal, or
  - the surface is fully covered with a moisture-tight covering until finishing operations are undertaken.

However, falsework that supports bottom forms (as for the top slab of a box culvert) must not be released until at least:

- 10 days have passed and at least 70 percent of the required strength has been achieved, or
- 5 days if the full strength has been attained.

# Finishing Concrete (Section 601-3.05(A))

The primary purposes of finishing formed surfaces are to:

- seal the surface from water and other elements that can rust or corrode metal ties and reinforcement within the concrete; and
- provide a uniform, pleasing appearance for surfaces that will remain visible to the public.

## Class I Finish (Section 601-3.05(B))

A Class I finish is required as the minimum for all formed and unformed surfaces. Ensure that:

- all metal ties are clipped or removed, including:
  - complete removal of tie rods, and
  - clipping or breaking off snap ties or tie wires so that the remaining portion is recessed to at least one inch below the surface;
- all recesses, holes, honeycombed spots, and other irregular areas that could provide openings into the concrete are:
  - cleaned to sound concrete,
  - moistened with water, and

- patched with mortar (consisting of 1 part cement, 2 parts sand, water, and an approved adhesive); and

- curing compound is applied, if the forms were removed for finishing before the full curing period has elapsed.

## Class II Finish (Section 601-3.05(C))

A Class II finish is required for formed surfaces that are normally visible to the public. If a pleasing appearance has not been achieved, either in the formed surface or at the joints, the Engineer will order that the surface be finished with a Class II finish. The inspector ensures that:

- rubbing shall continue until irregularities are removed and there is no excess material;
- at the time a light dust appears, the surface shall be brushed or sacked in one direction to produce a uniform texture and color;
- the surface is uniformly rubbed with:
  - cork, wood, or rubber floats,
  - polystyrene, or
  - a mechanical carborundum stone:
- any mortar used to facilitate rubbing:
  - is used in small enough amounts to produce a lather without plaster-coating the surface, and
  - matches the color of the surrounding concrete;
- the surface is brushed or sacked uniformly in one direction until a light dust appears; and
- if the surface is finished before the full curing period has passed:
  - other exposed surfaces are kept covered with a moisture-tight covering except during actual finishing operations, and
  - curing compound is applied after the finishing work is completed.

# Backfill Placement (Section 203-5.01(B), 203-10.03, Std. Dr. B19.50 and C3.10)

Backfilling is the final step in the basic concrete construction process. Ensure that the structure is properly backfilled by ensuring that:

- backfilling is not started for cast-in-place structures not designed to retain earth loads until at least:
  - 72 hours after placement, and the concrete has developed its full design strength;
  - until the concrete has developed its full design strength;
- the specified type of backfill material is used; and
- the backfill material is properly placed and compacted, including:
  - placing it in uniform layers of not more than 8 inches before compaction,
  - layering and compacting the material uniformly on all sides of the structure,

- compacting each layer with mechanical or pneumatic tampers or rollers to 95 percent of the maximum density, and
- completing the backfill without disturbing or damaging the structure.

# Section Three Quiz

1. In constructing an expansion joint, the joint material is placed … (Circle one or more)

   a. at the bottom of the joint to the specified partial depth of the joint.
   b. to the full depth and length of the joint.
   c. after the joint has been sawed.
   d. after the concrete is fully cured.

2. Which of the following types of incidental structures would generally **not** require any weakened-plane joints? (Circle one or more)

   a. curb and gutter
   b. catch basins
   c. sidewalks
   d. box culverts

3. In making a concrete construction joint, which of the following must be done before the next pour is started? (Circle one or more)

   a. The previous pour must be fully cured to at least seven days.
   b. The surface from the previous pour must be saturated with water.
   c. An appropriate type of joint materials is installed.
   d. The surface from the previous pour must be cleaned free of any laitance.
   e. All reinforcement must be clipped off at least one inch below the surface.

4. Except when a rapid-curing concrete is used, cast-in-place pours must be cured for at least … (Circle one)

   a. 24 hours.
   b. 3 days.
   c. 7 days.
   d. 28 days.

5. Which of the following curing methods is required for all concrete structures? (Circle one or more)

   a. forms-in-place curing
   b. water curing
   c. curing compound
   d. any one or combination of the above three methods
   e. none of the above

6. Which of the following practices should **not** be allowed in Class I finishing of a formed surface? (Circle one or more)

   a. clipping metal tie rods ½-inch below the surface
   b. removing loose aggregates from a honeycombed area
   c. moistening recesses with water before patching
   d. using a mortar consisting of 2 parts cement, 1 part sand and 2 parts water

7. Which of the following practices should **not** be allowed in Class II finishing? (Circle one or more)

   a. patching metal tie rod recesses as in Class I finishing
   b. using enough mortar to produce a plaster coating
   c. using wood or rubber floats
   d. brushing or sacking the surface in four directions

8. Which of the following practices should **not** be allowed in backfilling around a structure? (Circle one or more)

   a. placing and compacting backfill material in 8-inch layer
   b. waiting for the structure to reach 2000 psi compressive strength before backfilling
   c. completely backfilling one side of a wall before starting to backfill the other side
   d. compact each layer to 95% of the maximum density

# Section Three Quiz Answers

1. b. to the full depth and length of the joint.

2. b. catch basins
   d. box culverts

3. b. the surface from the previous pour must be saturated with water
   d. the surface from the previous pour must be cleaned free of any laitance

4. c. 7 days.

5. d. any one or a combination of the above three methods

6. a. clipping metal tie rods ½-inch below the surface
   d. using a mortar consisting of 2 parts cement, 1 part sand and 2 parts water

7. b. using enough mortar to produce a plaster coating
   d. brushing or sacking the surface in four directions

8. c. completely backfilling one side of a wall before starring to backfill the other side

# Section Four: Summary of Key Requirements

Most of this course has dealt with incidental concrete structures in terms of their similarities in the basic concrete construction procedures. This section summarizes some of the key differences among different structures for general comparison purposes.

## Curb and Gutter, Sidewalks, and Driveways (Section 908)

There are a number of key variations and requirements for curb, gutter, sidewalks and driveways, including:

- special requirements for compaction of the foundation;
- the lack of reinforcement in these structures;
- the option of constructing curb, gutter, and sidewalks by cast-in-place:
  - fixed-form, or
  - slip-form;
- specific standard intervals and dimensions for expansion and weakened-plane joints;
- required straightedge tolerances (¼-inch per 10 ft.) for:
  - the face, top, back, and flowline of curb and gutter, and
  - sidewalks;
- joint material shall be recessed as determined by the plans
- a requirement for a final, light brush finish;
- the use of curing-compound applied at a minimum of 1 gallon per 150 square feet; and
- a requirement of 60 percent of the specified 28-day strength before the structure can be put into service;
- early removal of forms requires curing.

Additional requirements and details for the construction of curbs, gutters, sidewalks and driveways are provided in Section 908 of the *Standard Specifications*, certain Standard Drawings and the contract plans.

## Catch Basins (Section 503)

Some of the key aspects that you should be aware of for catch basins are:

- that they can be:
  - cast-in-place by fixed-form methods, or
  - precast concrete sections;
- the proper types, dimensions and placement of such structural steel as anchor bolts, nose angles, grate frames and grates;
- the slope requirements for slump and wing basin floors; and

- the relationship of the catch basin with adjacent curb, gutter and sidewalk in terms of:
  - matching lines and grades, and
  - expansion joints between the structures.

Specific requirements for catch basins can be found in Section 503 of the *Standard Specifications* and various Standard Drawings as well as the project plans.

## Barrier Walls (Section 910)

In the inspection of concrete barrier walls, you should realize that:

- they may be constructed by:
  - fixed-form, cast-in-place,
  - slip-form, cast-in-place, or
  - precast sections;
- there are specific requirements for barrier walls, depending on the construction method used for:
  - the foundation,
  - reinforcement, and
  - joints; and
- a Class II finish is required.

These and other special requirements for barrier walls are provided in Section 910 of the *Standard Specifications* and in various Standard Drawings.

## Headwalls and Retaining Walls (Sections 502-3 and 601)

Culvert headwalls and retaining walls generally follow the basic concrete construction processes already discussed. The key considerations for these structures are that they:

- may be constructed using either:
  - fixed-form, cast-in-place methods, or
  - precast concrete sections;
- when cast-in-place, particular attention should be given to:
  - the proper layering and consolidation of the mix to minimize honeycombing and avoid cold joints, and
  - the specified locations and methods for construction joints; and
- particular attention should be given to avoiding displacement of vertical walls when backfill is placed and compacted (including earth reinforcement that is usually required for precast retaining walls).

Culvert headwalls and retaining walls are generally governed by Section 601 of the *Standard Specifications*. Specific details for headwalls and retaining walls can be found in the Standard Drawings as well as the contract plans.

# Ditch and Slope Pavements (Sections 601 and 912)

The primary consideration for ditch or slope pavement is the placement of the concrete on a sloped surface. Key variations for ditch pavement are that:

- the foundation must be finely graded to the correct slope;
- welded-wire mesh is more commonly used as reinforcement which is typically placed by:
  - laying it out directly on the slope before the pour, and
  - pulling it up into position with a hook as the concrete is placed;
- placement may be by:
  - fixed-form concrete,
  - slip-form concrete, or
  - shotcrete;
- concrete placement usually involves:
  - working from the top of the slope down to the bottom, and
  - using a roller screed, tramping devices or other methods to consolidate the mix without encouraging its tendency to flow down the slope;
- the surface must be struck off with a strike-board or screed (except shotcrete); and an exposed-aggregate finish sometimes may be required.

Ditch and slope pavements are generally governed by Section 601 of the *Standard Specifications* (or 912, if shotcrete is specified). Details are provided in the contract plans and special provisions.

# Section Five: Concrete Box Culverts

The primary considerations for box culverts relate to their relative size and load-bearing function.

## Key Points

The key points to watch for include:

- the specified sizes, shapes, positions, and quantities of reinforcing steel ;
- the specified concrete (class S and strength);
- compliance with the specified pour sequence and locations of construction joints;
- the uniform screeding and finishing of the bottom slab to the correct grades to minimize ponding of water in the culvert;
- the proper placement and maintenance (for at least 7 days) of the falsework for the top slab; and
- proper backfilling around and over the completed structure.

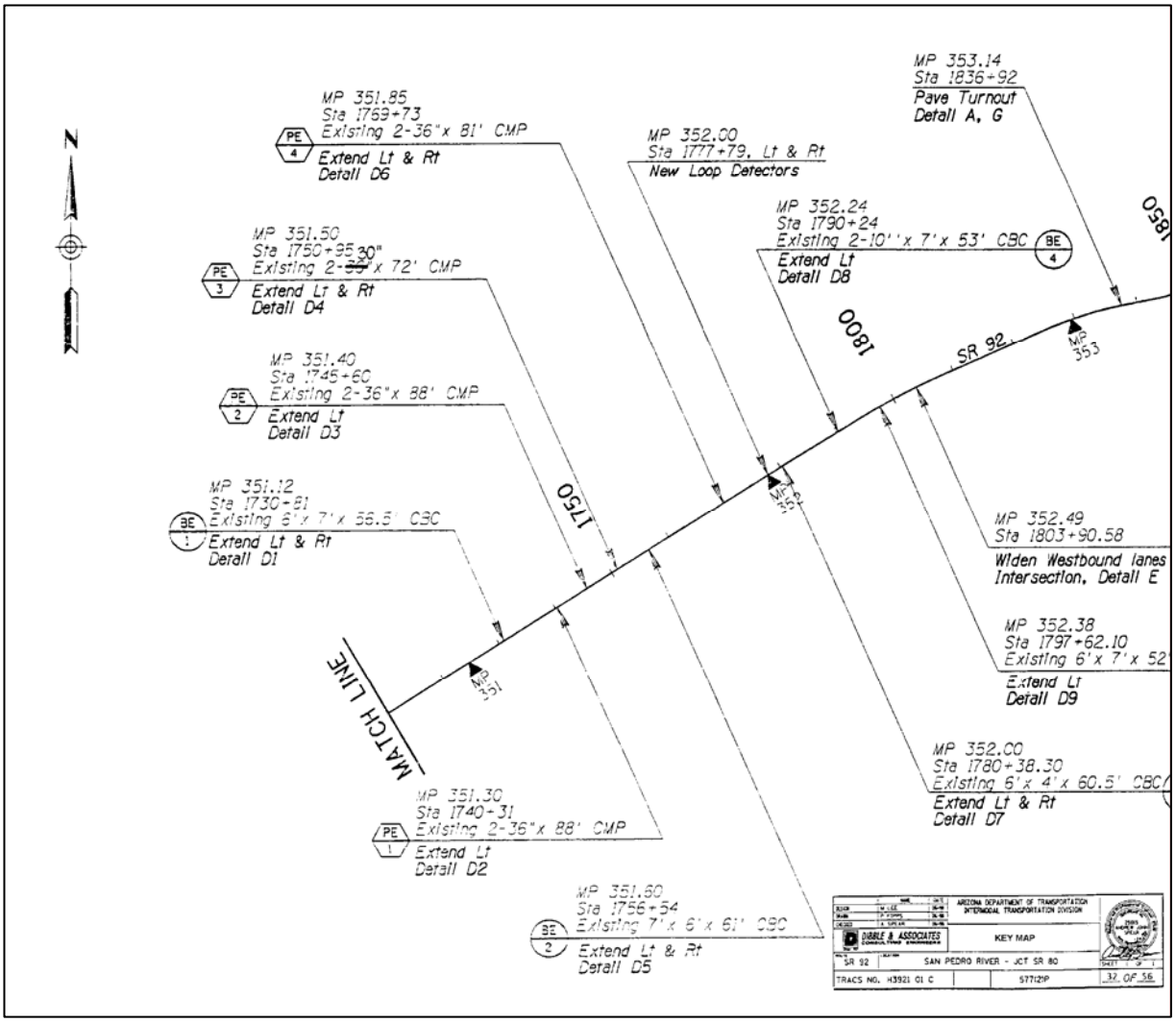
## Reading Plans and Drawings

Box culverts are governed by Section 601 of the *Standard Specifications* with details provided by the standard drawings and the contract plans.

The details of a box culvert will be in the contract plans (under Roadway Plans, Key Map, and Details), and the standard drawings or bridge drawings #01.10-08.20.

### Key Map

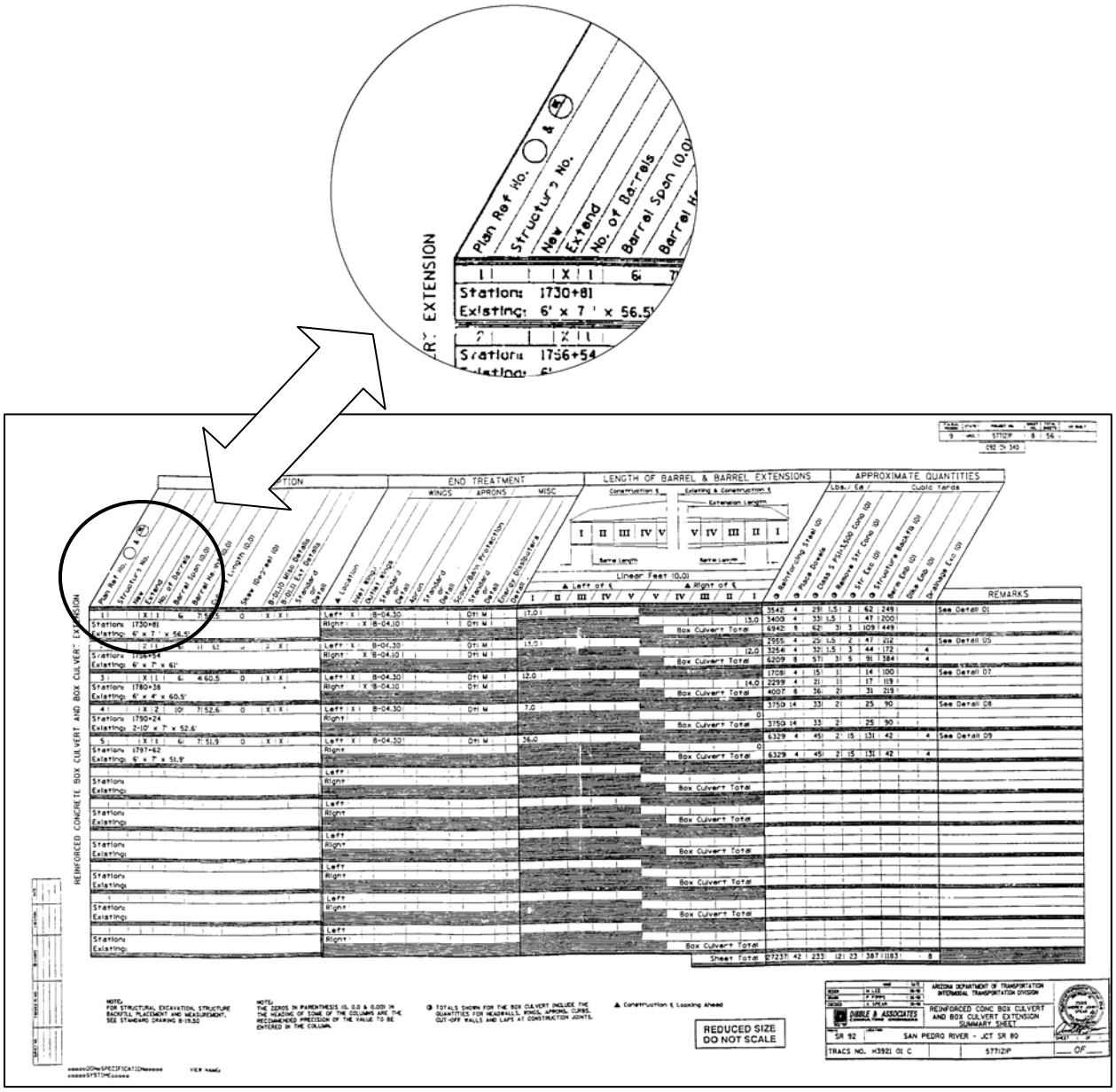
The location of the box culvert will be found in the roadway plan sheets (or "key map"). It is important that the inspector visit the general location of a box culvert.




Notice that the designation for Box Extension #1 is shown as (BE 1) with mile post and stationing location. A reference to drawing Detail D1 is also mentioned.

## Summary Sheets

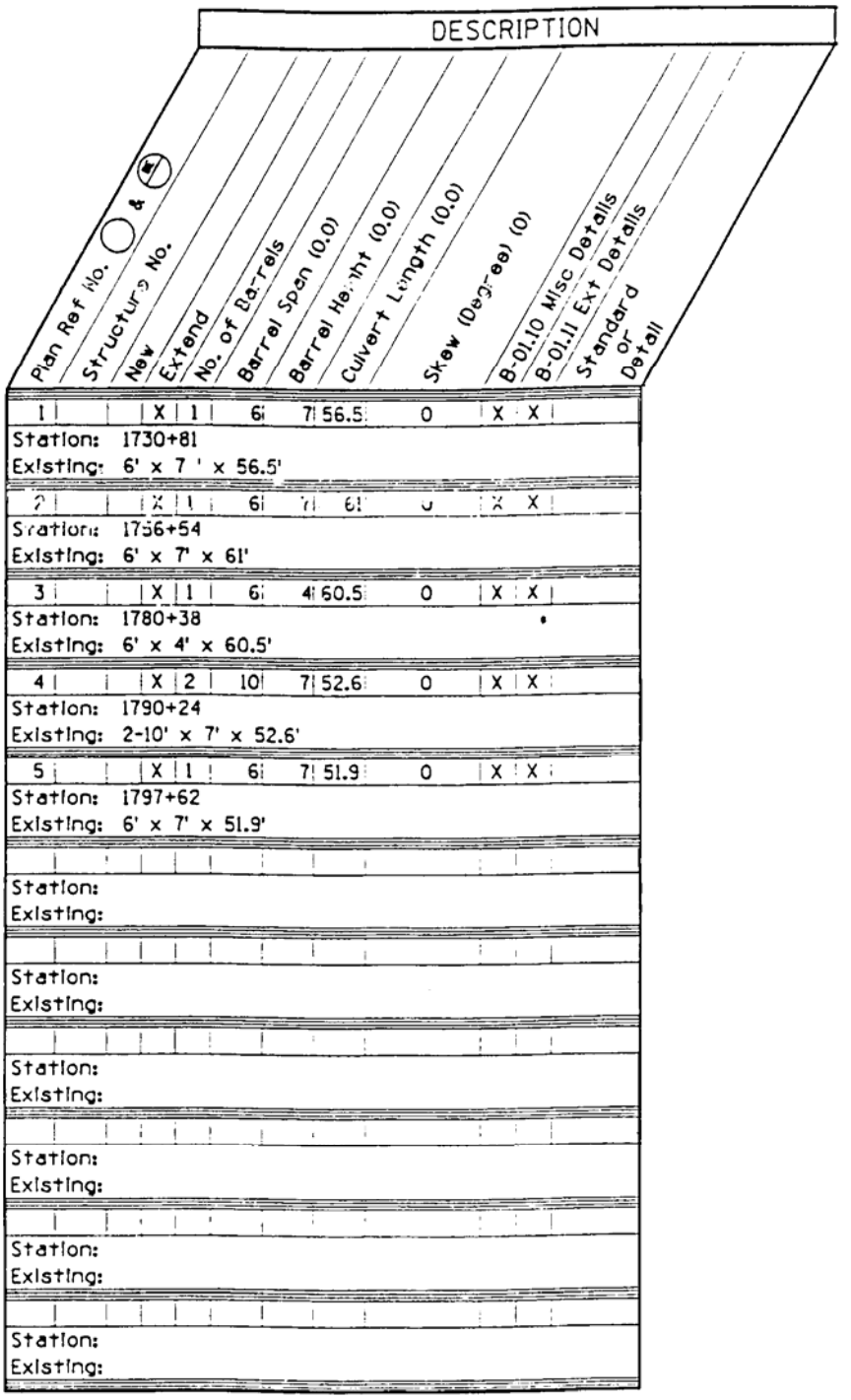
The size of the box will be found in the summary sheets of the plans. From the roadway plans the inspector can find a plan reference number, (1) or (BE/1) which will be used with the summary sheets.




Using the plans reference number the inspector can determine the description, end treatment, length or extension, and approximate quantities from the summary sheets.

## Description

Under description the following details will be shown: plan reference number, structure number, new or extended box, number of barrels, barrel span, barrel height, culvert length, skew angle, and B standard detail drawings.



DESCRIPTION

| Plan Ref No. ◯ & (◯) | Structure No. | New | Extend | No. of Barrels | Barrel Span (0.0) | Barrel Height (0.0) | Culvert Length (0.0) | Skew (Degree) (0) | B-01.10 Misc Details | B-01.11 Ext Details | Standard or Detail |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | X | 1 | 6 | 7 | 56.5 | 0 | X | X | |
| Station: 1730+81 | | | | | | | | | | | |
| Existing: 6' x 7 ' x 56.5' | | | | | | | | | | | |
| 2 | | | X | 1 | 6 | 7 | 61 | 0 | X | X | |
| Station: 1756+54 | | | | | | | | | | | |
| Existing: 6' x 7' x 61' | | | | | | | | | | | |
| 3 | | | X | 1 | 6 | 4 | 60.5 | 0 | X | X | |
| Station: 1780+38 | | | | | | | | | | | |
| Existing: 6' x 4' x 60.5' | | | | | | | | | | | |
| 4 | | | X | 2 | 10 | 7 | 52.6 | 0 | X | X | |
| Station: 1790+24 | | | | | | | | | | | |
| Existing: 2-10' x 7' x 52.6' | | | | | | | | | | | |
| 5 | | | X | 1 | 6 | 7 | 51.9 | 0 | X | X | |
| Station: 1797+62 | | | | | | | | | | | |
| Existing: 6' x 7' x 51.9' | | | | | | | | | | | |
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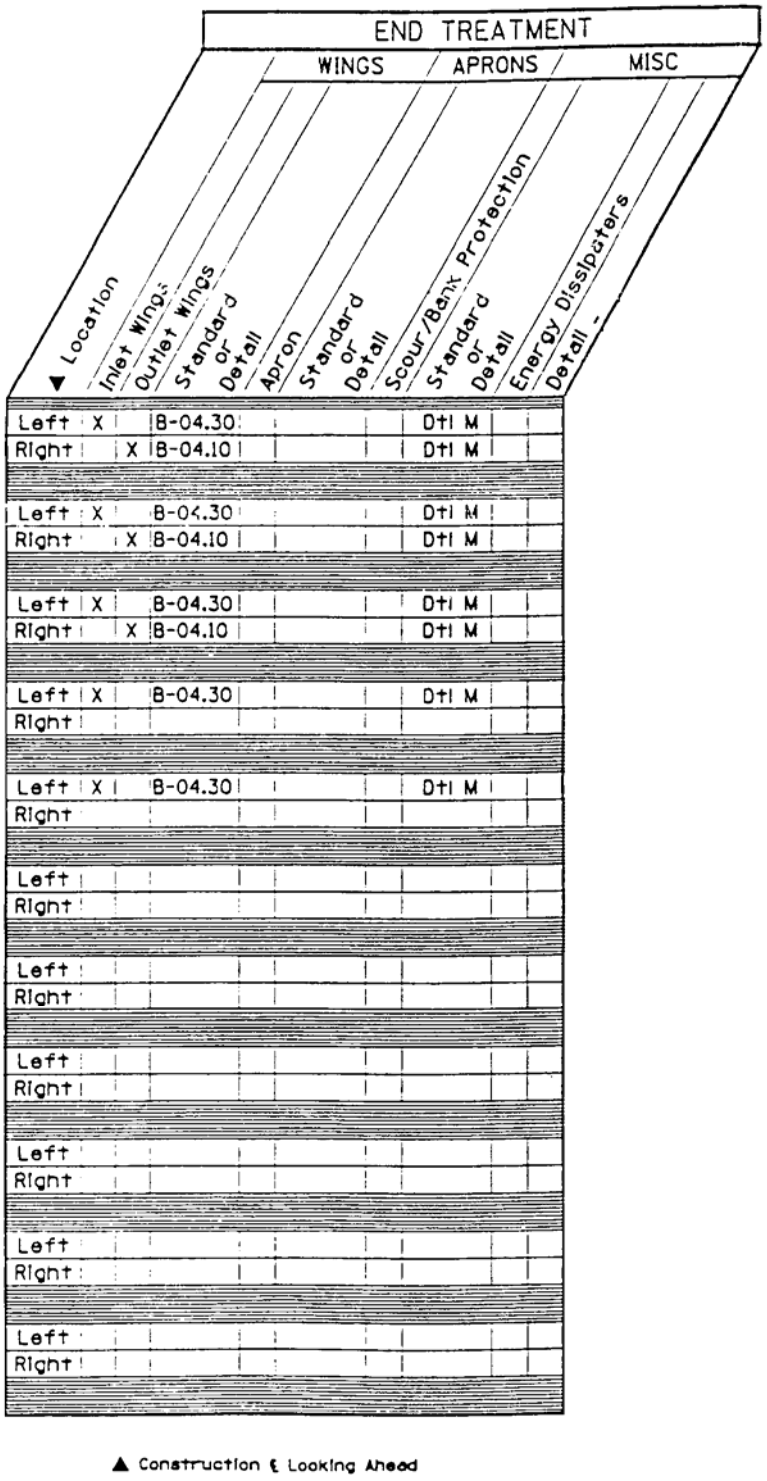
NOTE:
FOR STRUCTURAL EXCAVATION, STRUCTURE BACKFILL PLACEMENT AND MEASUREMENT, SEE STANDARD DRAWING B-19.50

NOTE:
THE ZEROS IN PARENTHESIS (0, 0.0 & 0.00) IN THE HEADING OF SOME OF THE COLUMNS ARE THE RECOMMENDED PRECISION OF THE VALUE TO BE ENTERED IN THE COLUMN.

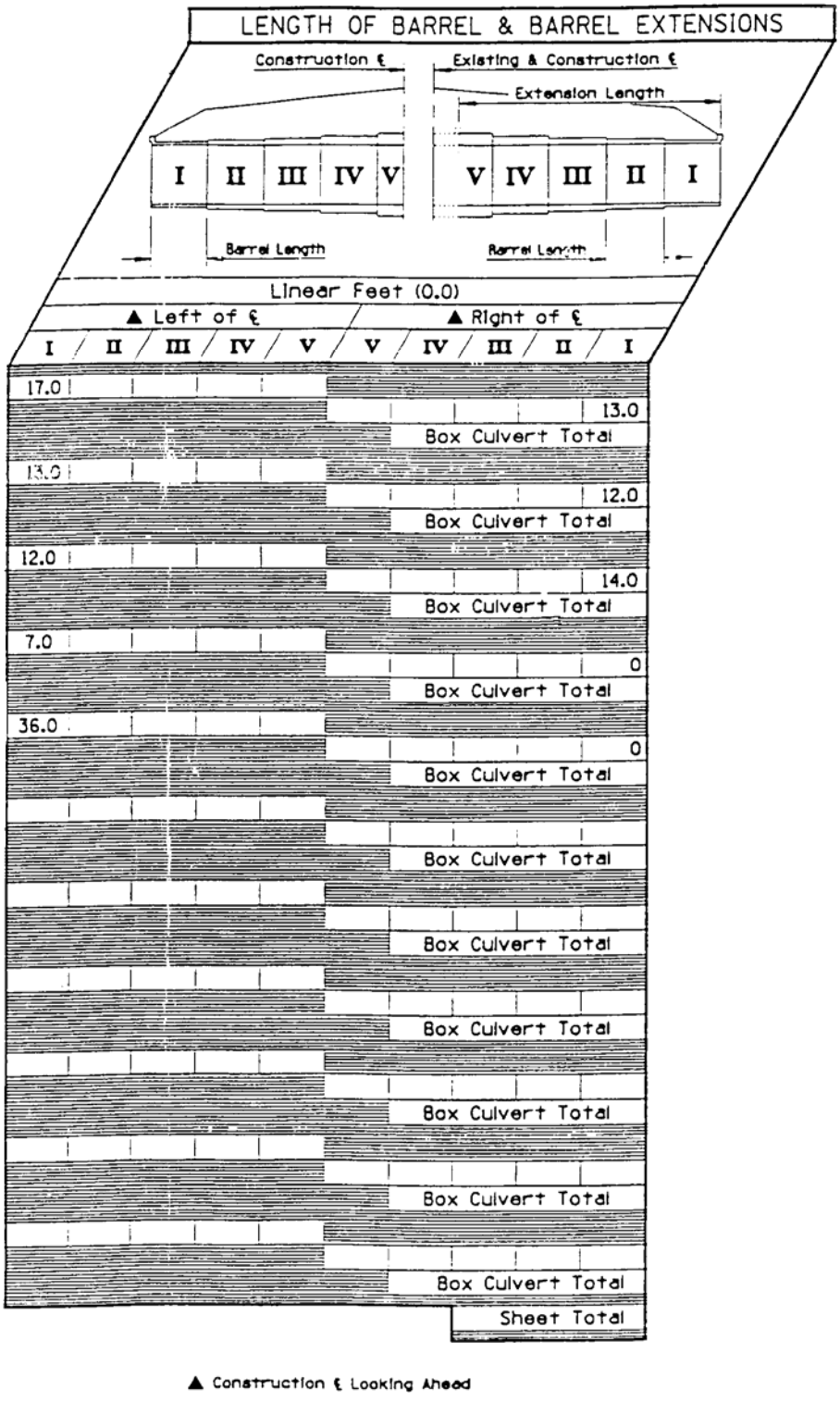
## End Treatment

Under end treatment the following details will be shown: location (left or right), wings (inlet or outlet), wing details B standard drawing, aprons with details, and miscellaneous details.



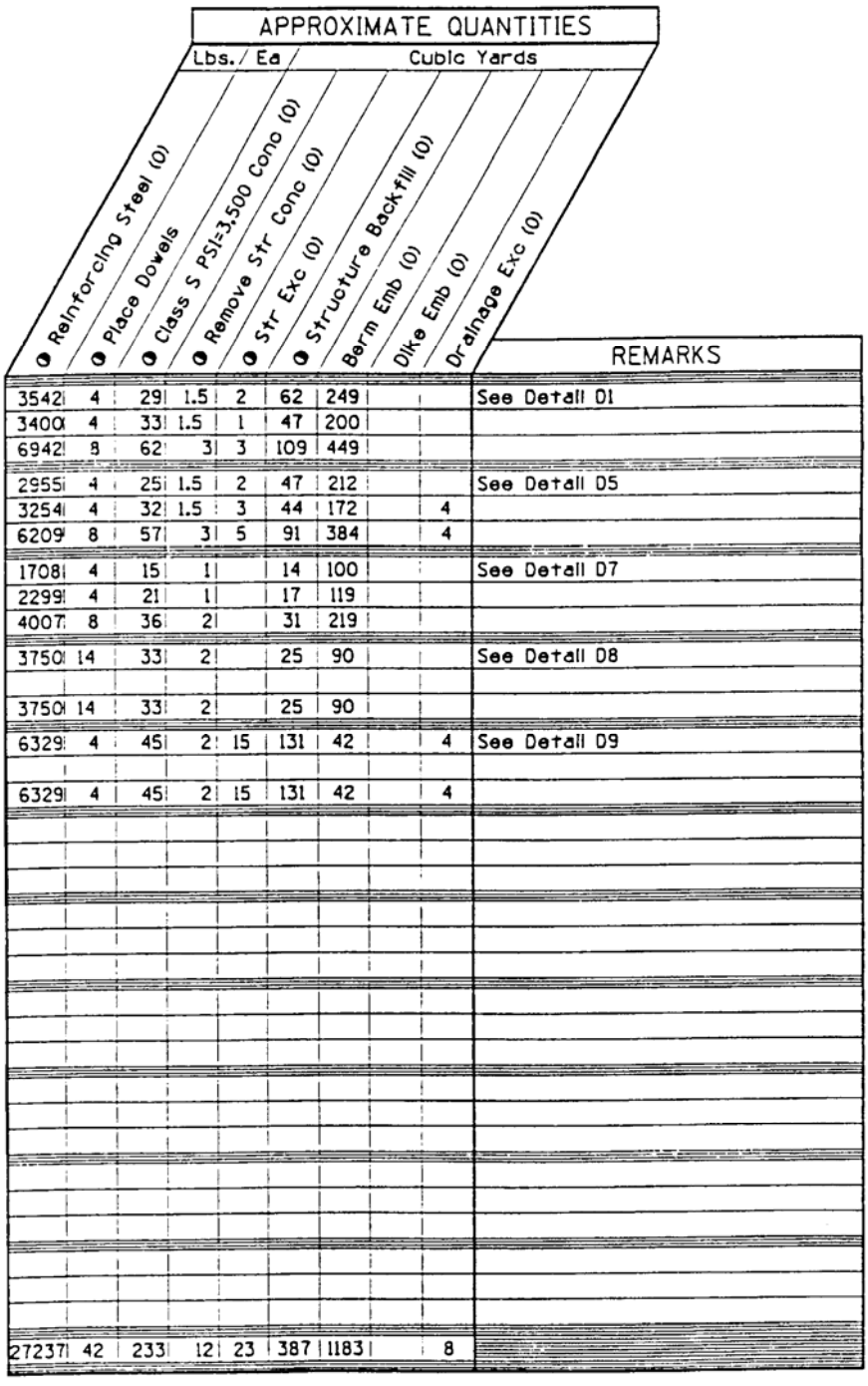
## Length of Barrel and Barrel Extensions

Under length of barrel and barrel extensions the following details will be shown: length and type of barrel and which table to be used from the B standard drawings for dimensions and reinforcement. Roman numerals correspond to different tables and the amount of fill over the box culvert.



## Approximate Quantities

Under approximate quantities, the amounts for that specific box will be given. Reinforcing steel is given in pounds; place dowels, class S concrete, remove structural concrete, structural excavation, structural backfill, berm embankment, dike embankment, and drainage excavation are all given in cubic yards.



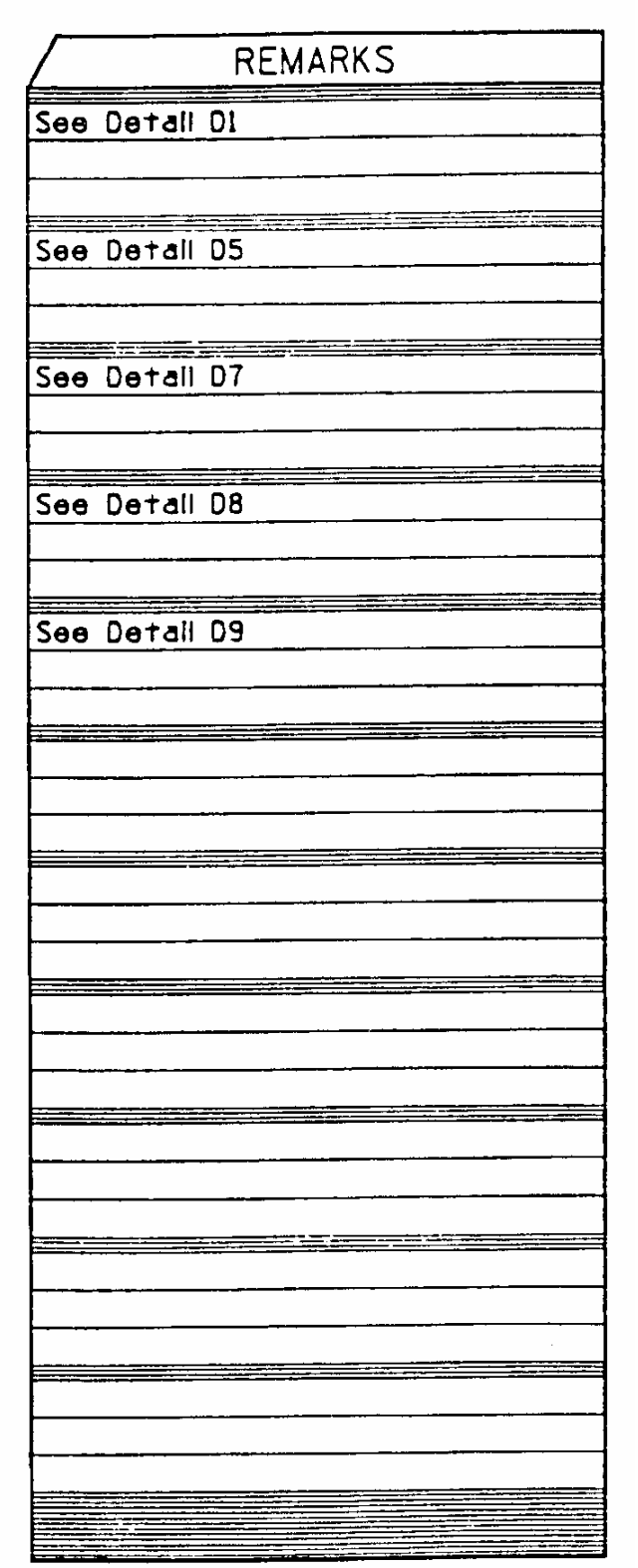
APPROXIMATE QUANTITIES

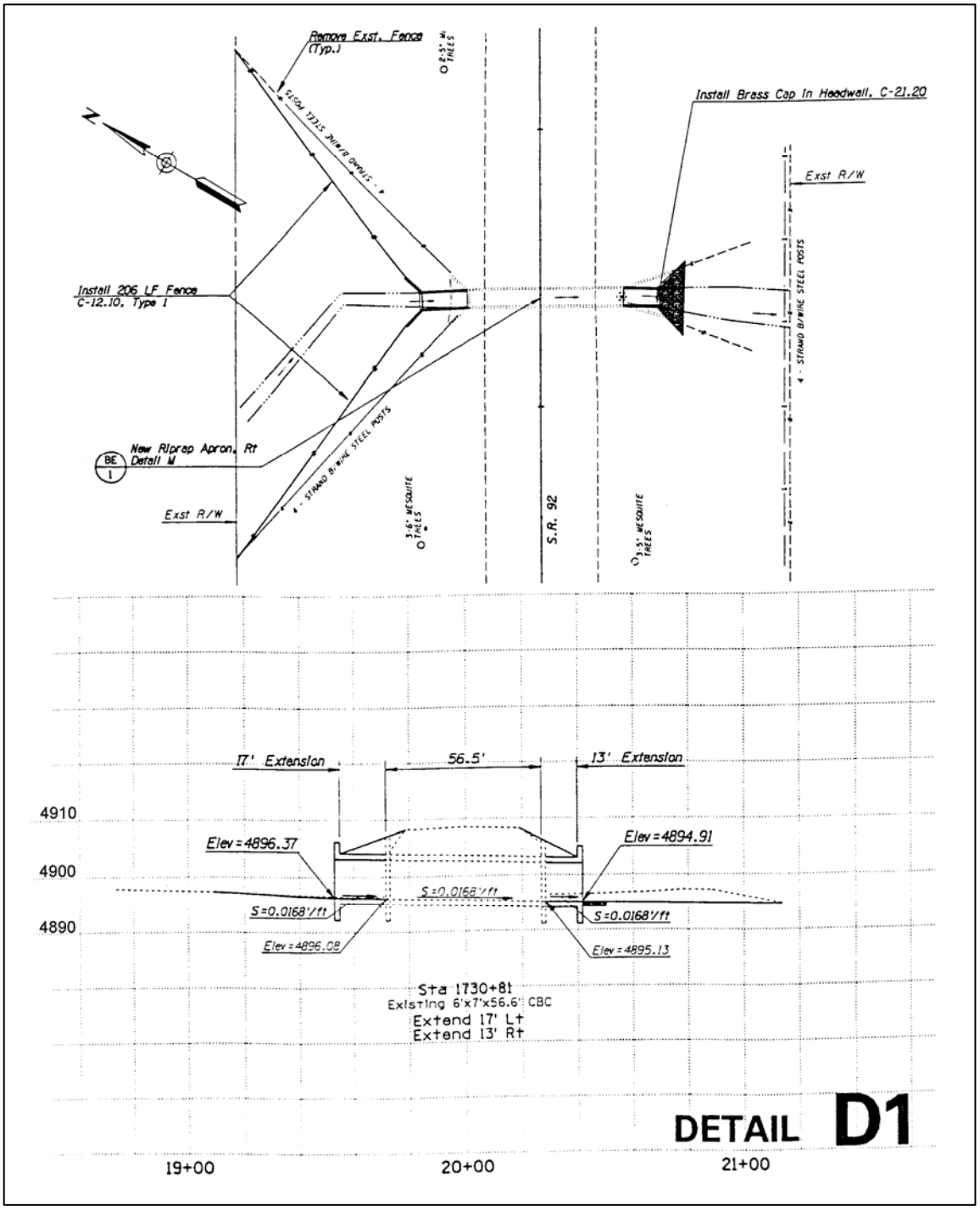
| Lbs./Ea | | Cubic Yards | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ◑ Reinforcing Steel (0) | ◑ Place Dowels | ◑ Class S PSI=3,500 Conc (0) | ◑ Remove Str Conc (0) | ◑ Str Exc (0) | ◑ Structure Backfill (0) | Berm Emb (0) | Dike Emb (0) | Drainage Exc (0) | REMARKS |
| 3542 | 4 | 29 | 1.5 | 2 | 62 | 249 | | | See Detail 01 |
| 3400 | 4 | 33 | 1.5 | 1 | 47 | 200 | | | |
| 6942 | 8 | 62 | 3 | 3 | 109 | 449 | | | |
| 2955 | 4 | 25 | 1.5 | 2 | 47 | 212 | | | See Detail 05 |
| 3254 | 4 | 32 | 1.5 | 3 | 44 | 172 | | 4 | |
| 6209 | 8 | 57 | 3 | 5 | 91 | 384 | | 4 | |
| 1708 | 4 | 15 | 1 | | 14 | 100 | | | See Detail 07 |
| 2299 | 4 | 21 | 1 | | 17 | 119 | | | |
| 4007 | 8 | 36 | 2 | | 31 | 219 | | | |
| 3750 | 14 | 33 | 2 | | 25 | 90 | | | See Detail 08 |
| 3750 | 14 | 33 | 2 | | 25 | 90 | | | |
| 6329 | 4 | 45 | 2 | 15 | 131 | 42 | | 4 | See Detail 09 |
| 6329 | 4 | 45 | 2 | 15 | 131 | 42 | | 4 | |
| 27237 | 42 | 233 | 12 | 23 | 387 | 1183 | | 8 | |

◑ TOTALS SHOWN FOR THE BOX CULVERT INCLUDE THE QUANTITIES FOR HEADWALLS, WINGS, APRONS, CURBS, CUT-OFF WALLS AND LAPS AT CONSTRUCTION JOINTS.

## Remarks

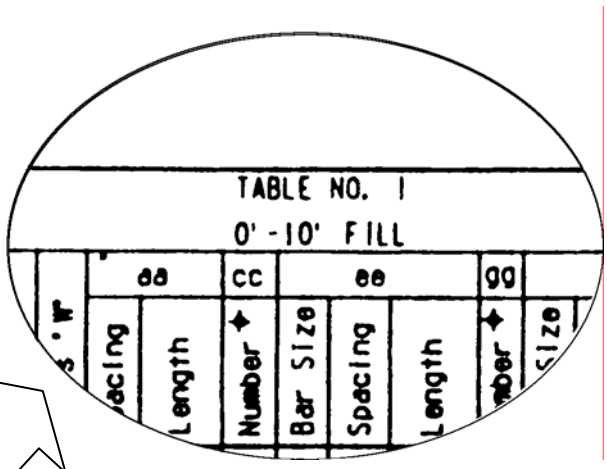
Other important information will be listed under the remarks column, notice that for box culvert extension # 1 the Remarks column refers to detail drawing D1.

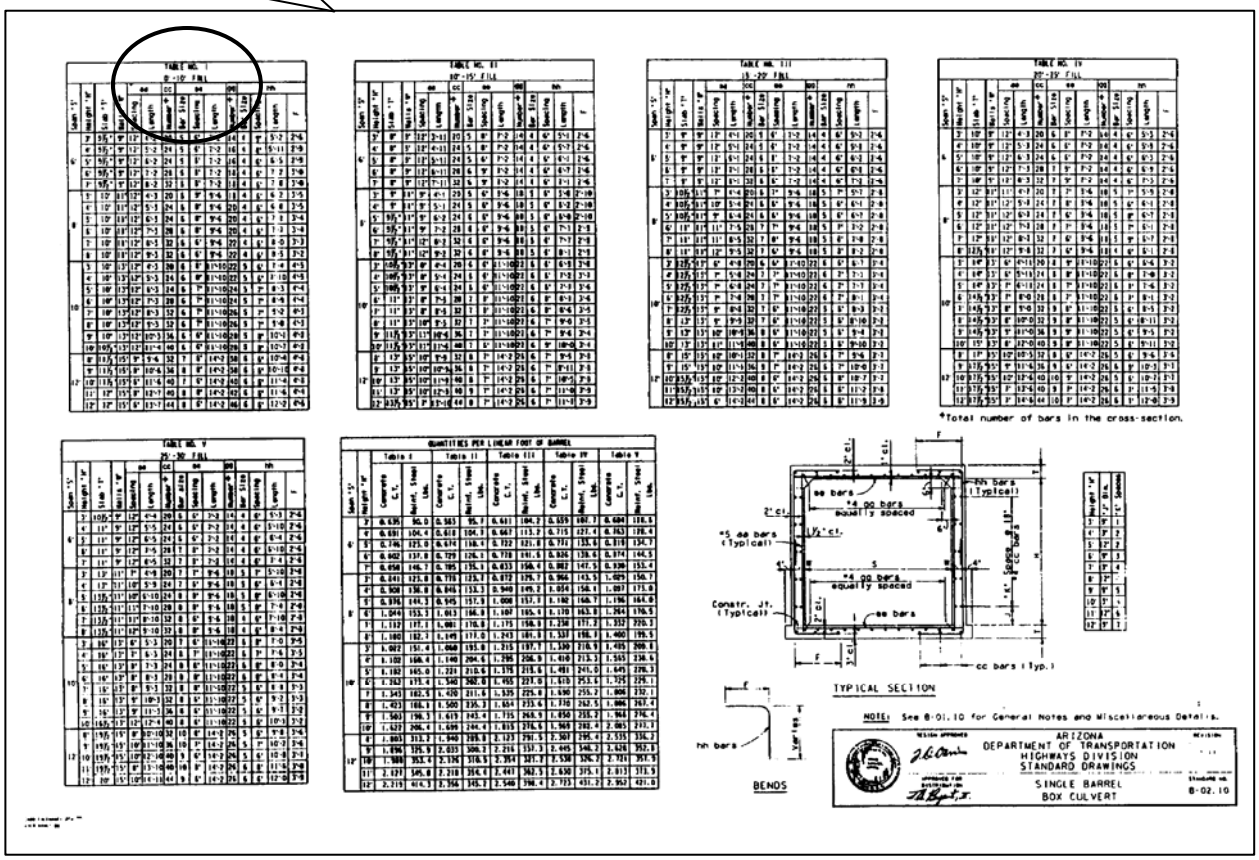





Plan detail drawings will have items or other information that is important to the R.C.B. culvert location, such items to look for are removal and installation of fence, a riprap apron on the right side, installation of a brass cap, elevations, slope direction, and the length of the extensions for both sides.

From the summary sheet item # 1 is a box extension that is 6’ wide by 7’ high (these are the interior dimensions) for a single barrel box, we can determine which table to use from the B Standard Drawings. For a single barrel box you would use drawing # B-02.10 table I for a box that is under a 0’ to 10’ fill; this corresponds to Roman numeral # I from the length of barrel & barrel extension column of the summary sheet.

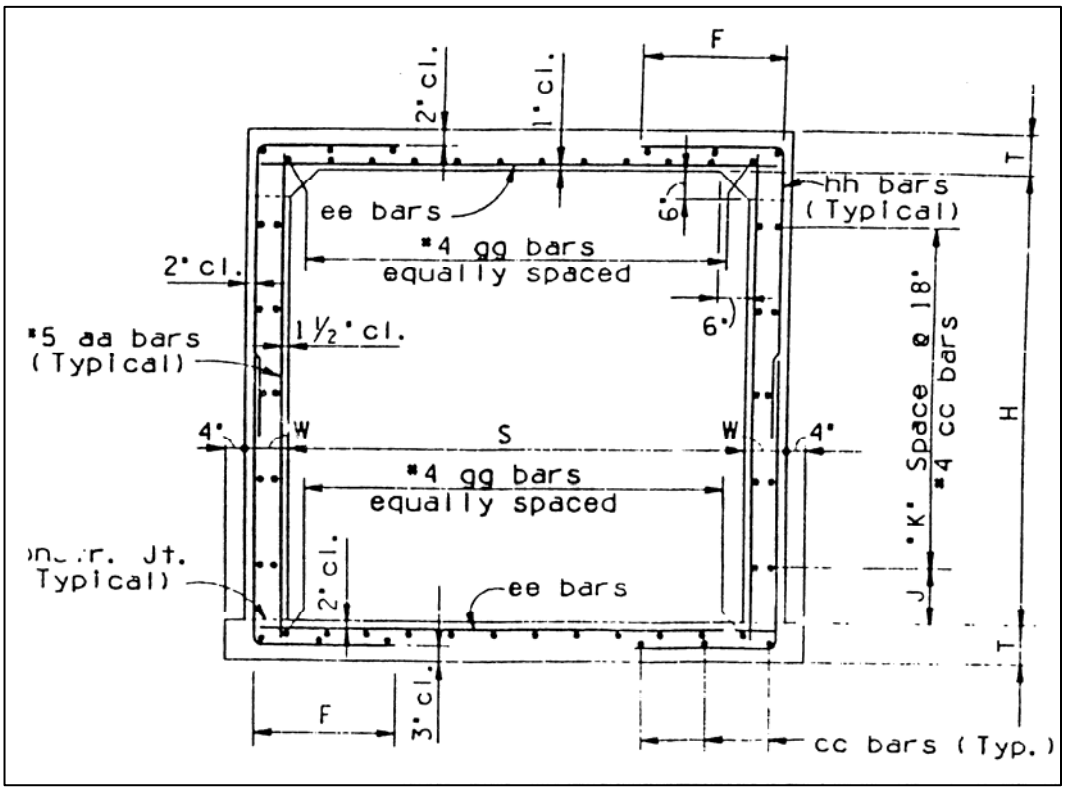


Looking at table #1 from B standard drawing B-02.10 you can now find the dimensions and reinforcement for a 6 X 7 box. The span (S) is 6', the height (H) is 7', the slabs (T) are 9½", the walls (W) are 9", the aa bars are spaced at 12" and length is 8'2", the cc bars are a total of 32, the ee bars are a size #6 spaced at 8" with a length of 7'2", the gg bars are a total of 18, the hh bars are a size # 4 spaced at 6" with a length of 7'8", the F dimension is the bend length which is 3' of the hh bar. If the sizes, spacing or length are not shown, you will have to look at the typical drawing on the same page of the B standard drawings.

TABLE NO. 1
0' - 10' FILL

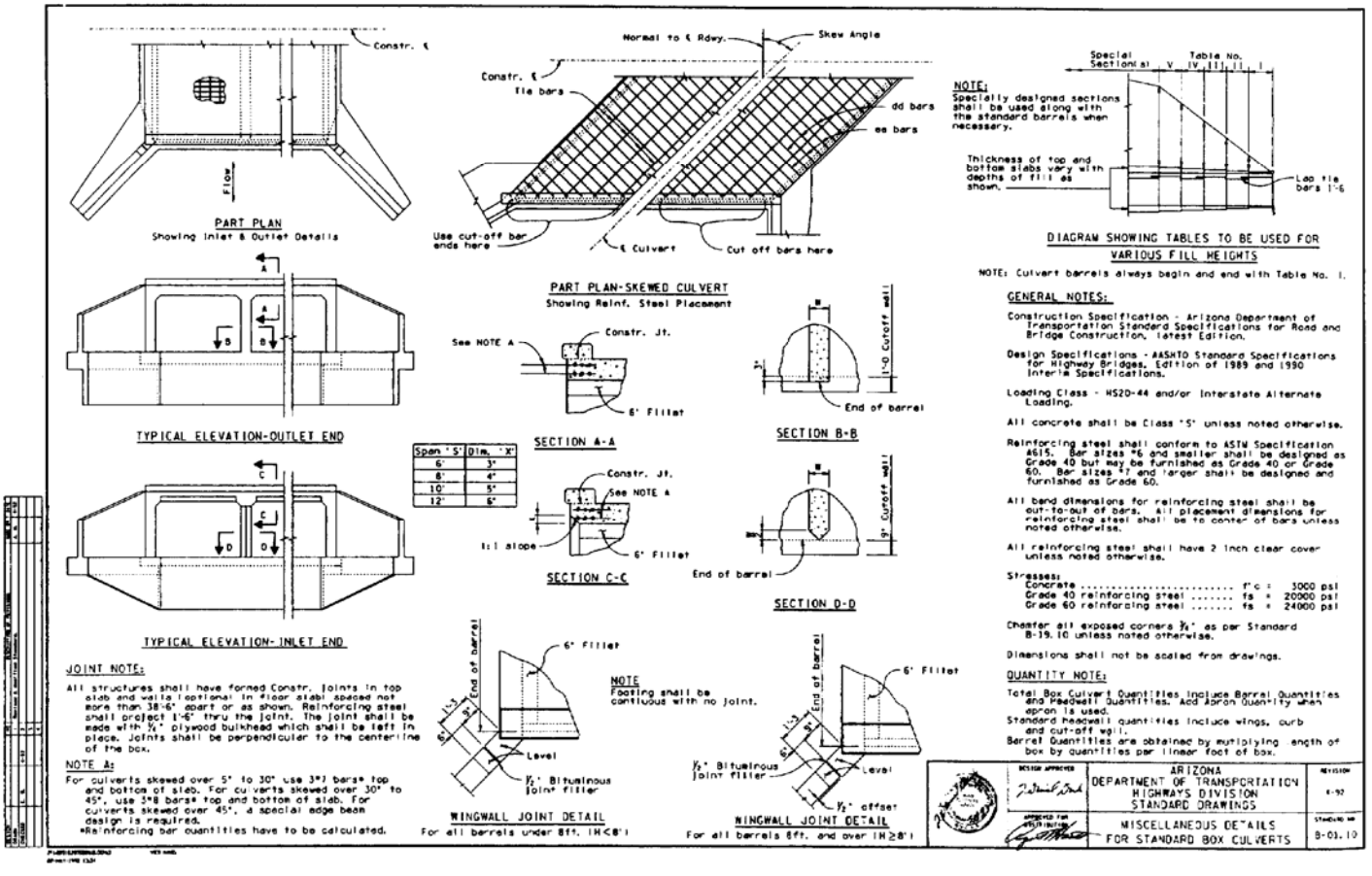
| Span 'S' | Height 'H' | Slab 'T' | Walls 'W' | aa | | cc | ee | | | gg | hh | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Spacing | Length | Number ✦ | Bar Size | Spacing | Length | Number ✦ | Bar Size | Spacing | Length | F |
| 6' | 3' | 9½" | 9" | 12" | 4'-2 | 20 | 5 | 6" | 7'-2 | 14 | 4 | 9" | 5'-2 | 2'-6 |
| | 4' | 9½" | 9" | 12" | 5'-2 | 24 | 5 | 6" | 7'-2 | 16 | 4 | 8" | 5'-11 | 2'-9 |
| | 5' | 9½" | 9" | 12" | 6'-2 | 24 | 5 | 6" | 7'-2 | 16 | 4 | 6" | 6'-5 | 2'-9 |
| | 6' | 9½" | 9" | 12" | 7'-2 | 28 | 6 | 8" | 7'-2 | 18 | 4 | 6" | 7'-2 | 3'-0 |
| | 7' | 9½" | 9" | 12" | 8'-2 | 32 | 6 | 8" | 7'-2 | 18 | 4 | 6" | 7'-8 | 3'-0 |
| 8' | 3' | 10" | 11" | 12" | 4'-3 | 20 | 6 | 9" | 9'-6 | 18 | 4 | 6" | 6'-2 | 3'-5 |
| | 4' | 10" | 11" | 12" | 5'-3 | 24 | 6 | 8" | 9'-6 | 20 | 4 | 6" | 6'-8 | 3'-5 |
| | 5' | 10" | 11" | 12" | 6'-3 | 24 | 6 | 8" | 9'-6 | 20 | 4 | 6" | 7'-1 | 3'-4 |
| | 6' | 10" | 11" | 12" | 7'-3 | 28 | 6 | 8" | 9'-6 | 20 | 4 | 6" | 7'-7 | 3'-4 |
| | 7' | 10" | 11" | 12" | 8'-3 | 32 | 6 | 6" | 9'-6 | 22 | 4 | 6" | 8'-0 | 3'-3 |
| | 8' | 10" | 11" | 12" | 9'-3 | 32 | 6 | 6" | 9'-6 | 22 | 4 | 6" | 8'-5 | 3'-2 |
| 10' | 3' | 10" | 13" | 12" | 4'-3 | 20 | 6 | 8" | 11'-10 | 22 | 5 | 6" | 7'-4 | 4'-5 |
| | 4' | 10" | 13" | 12" | 5'-3 | 24 | 6 | 8" | 11'-10 | 22 | 5 | 6" | 7'-10 | 4'-5 |
| | 5' | 10" | 13" | 12" | 6'-3 | 24 | 6 | 7" | 11'-10 | 24 | 5 | 7" | 8'-3 | 4'-4 |
| | 6' | 10" | 13" | 12" | 7'-3 | 28 | 6 | 7" | 11'-10 | 24 | 5 | 7" | 8'-9 | 4'-4 |
| | 7' | 10" | 13" | 12" | 8'-3 | 32 | 6 | 7" | 11'-10 | 26 | 5 | 7" | 9'-2 | 4'-3 |
| | 8' | 10" | 13" | 12" | 9'-3 | 32 | 6 | 7" | 11'-10 | 26 | 5 | 7" | 9'-8 | 4'-3 |
| | 9' | 10" | 13" | 12" | 10'-3 | 36 | 6 | 6" | 11'-10 | 28 | 5 | 8" | 10'-1 | 4'-2 |
| | 10' | 10½" | 13" | 12" | 11'-4 | 40 | 6 | 6" | 11'-10 | 28 | 5 | 8" | 10'-7 | 4'-2 |
| 12' | 8' | 11½" | 15" | 9" | 9'-6 | 32 | 7 | 6" | 14'-2 | 38 | 6 | 6" | 10'-4 | 4'-8 |
| | 9' | 11½" | 15" | 8" | 10'-6 | 36 | 8 | 8" | 14'-2 | 38 | 6 | 6" | 10'-10 | 4'-8 |
| | 10' | 11½" | 15" | 6" | 11'-6 | 40 | 7 | 6" | 14'-2 | 40 | 6 | 6" | 11'-4 | 4'-8 |
| | 11' | 12" | 15" | 8" | 12'-7 | 40 | 8 | 8" | 14'-2 | 42 | 6 | 6" | 11'-6 | 4'-4 |
| | 12' | 12" | 15" | 6" | 13'-7 | 44 | 8 | 6" | 14'-2 | 46 | 6 | 6" | 12'-2 | 4'-6 |

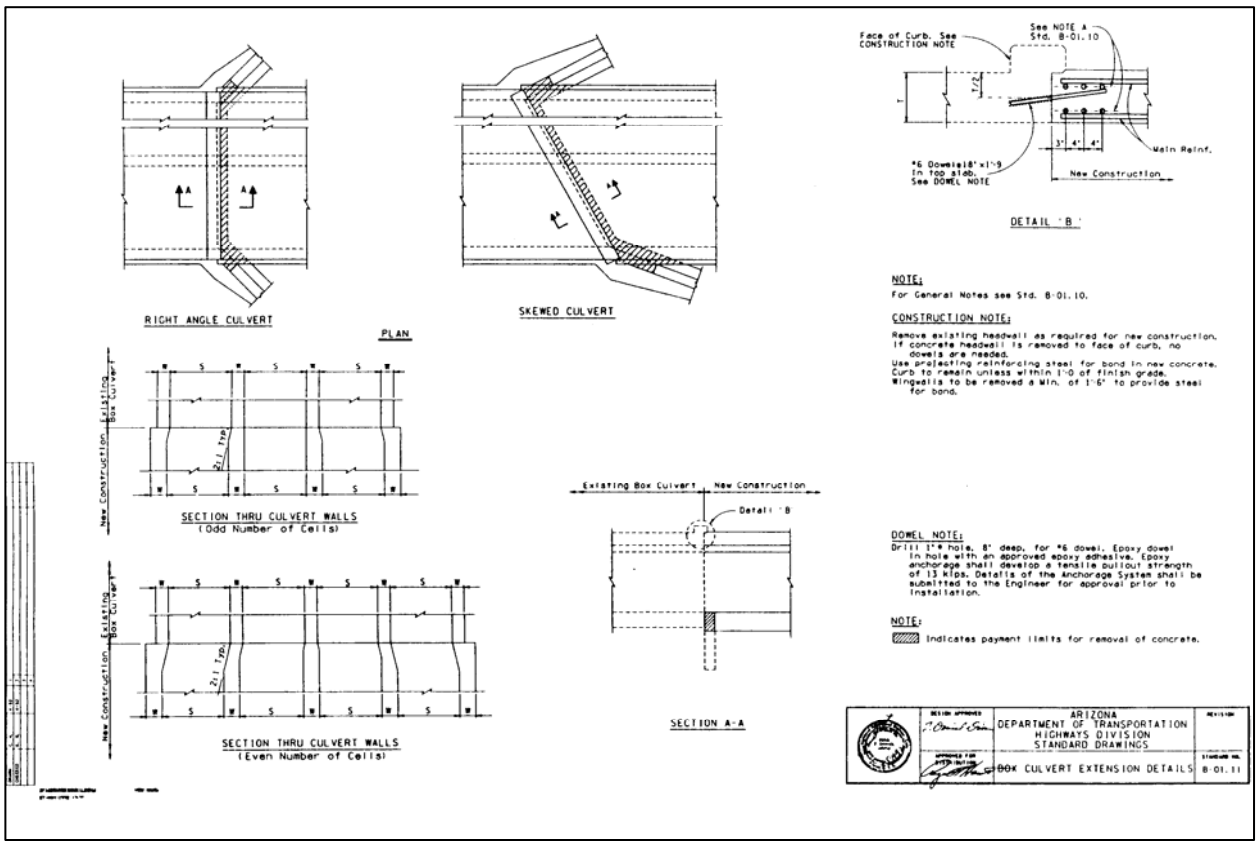



| Height "H" | "J" Dimension | "K" Spaces |
|---|---|---|
| 3' | 9' | 1 |
| 4' | 3' | 2 |
| 5' | 12' | 2 |
| 6' | 9' | 3 |
| 7' | 3' | 4 |
| 8' | 12' | 4 |
| 9' | 9' | 5 |
| 10' | 3' | 5 |
| 11' | 12' | 6 |
| 12' | 9' | 7 |

**Typical section from B02.10 Detailed Reinforcement Location**

Other drawings that should be looked at for concrete box culvert are the B-01.10 (miscellaneous details), as shown below, and the B-01.11 (extension details), as shown on page 52.






For box culverts with multiple barrels drawings B-02.20 through B-02.70 will be used, (notice that drawing B-02.70 is the quantities for multiple barrels). Drawing B-03.10 is an equipment pass, drawings B-04.10 through B-08.20 are inlet wing, outlet wing, and apron details with different quantities for heights, skews and slopes. Drawing B-19.50 is the structural excavation & backfill for R.C.B. culvert detail.

# Section Five Quiz

1. Which ADOT Standard Drawing would an inspector use to inspect the backfill of a box culvert?

   a. B-02.70
   b. C-03.10
   c. B-19.50

2. Where in the ADOT Bridge Standard Drawings would you find the culvert quantities for a triple barrel box culvert?

   a. B-02.70
   b. B-02.10
   c. B-02.20

3. Where in the ADOT Bridge Standard Drawings would you find the details for a box extension?

   a. B-19.50
   b. B-06.10
   c. B-01.11

4. Which plan sheet will show the elevations for the box culvert?

   a. summary sheet
   b. culvert detail (D-1) sheet
   c. key map sheet

5. Which plan sheet will show what table to use for the box culverts?

   a. summary sheet
   b. key map
   c. culvert detail sheet

6. Using the ADOT Bridge Standard Drawing B-02.10 Table No. I, what is the slab (T) dimension for a 10’ X 10’ box culvert?

   a. 11 ½ inch
   b. 10 ½ inch
   c. 16 ½ inch

# Section Five Quiz Answers

1. c. B-19.50
2. a. B-02.70
3. c. B-01.11
4. b. culvert detail (D-1) sheet
5. a. summary sheet
6. b. 10 ½ inch

# Section Six: Documentation

This section summarizes the documentation involved in inspecting incidental concrete structures construction in terms of:

- measurements as the basis for payment,
- key information and events to be documented, and
- the records and reports used.

## Measurement for Payment

The unit-measurement basis is generally more common for incidental structures and includes:

- for curb and gutter – per linear foot, measured along the flow line (excluding catch basins) yet including depressed curb for driveways;
- for sidewalks and driveways – per square foot (excluding catch basins) and wheel chair ramps;
- for catch basins – per unit;
- for barrier walls – per linear foot, measured along the centerline of the top surface;
- for culvert headwalls – per unit;
- for retaining walls – as specified in the special provisions, usually either:
  - per linear foot (if uniform in height), or
  - per square foot,
  - footings paid separately by cubic yards and reinforcing steel by the pound;
- for ditch or slope pavement – per square foot; and
- for box culverts – per unit
  - line items (lump-sum).

When the contract calls for line-item payments, measurements are made for such line items as:

- cubic yards of excavation, as calculated from the pay limits specified in the plans,
- pounds of reinforcing steel, determined by:
  - confirming that the actual numbers of each size, length and shape of bar used are as specified in the plans, and
  - converting the lengths of each bar size into pounds using the appropriate pounds-per-linear-foot factor;[9]
- cubic yards of concrete, based on the calculated volume of the structure as shown in the plans; and
- cubic yards of backfill, as calculated from the pay limits shown in the plans.

[9] Reinforcing steel may also be specified for payment on a lump-sum basis.

The *Standard Specifications* (Section 601) also provides for adjustment of the contracted unit price for concrete structures according to the following conditions:

| **Adjustment in Contract Unit Price for Deficiency in Strength of Structural Concrete** | |
|---|---|
| Percent of Specified 28-Day Compressive Strength Attained, to the Nearest One Percent | Percent of Contract Unit Price Allowed |
| 100 or more | 100 |
| 98-99 | 95 |
| 96-97 | 90 |
| 95 | 85 |
| Less than 95<br>(if the structure is allowed to remain in place) | 55 |

## Key Information and Events

Some of the key information and events that need to be documented for incidental concrete structures is similar to that of any construction work including:

- routine information – such as the type of work being done, the project, the location, the time of the work and the weather; and
- special events or problems – including any unusual conditions, instructions to the Contractor regarding rejected work or materials, and corrective actions taken by the Contractor.

Other key items of information and events that need to be documented specifically for concrete construction operations include:

- alignment and grade control information;
- calculations and diagrams for structural excavation quantities;
- materials control information, including:
  - the concrete mix design,
  - concrete sampling and testing results, and
  - certification and sampling information for related materials;
- concrete quantities, batch times, waste, temperatures and discharge times;
- joint locations and construction methods;
- times and methods used for curing, forms removal, finishing and backfilling; and
- note on the ticket where the concrete was placed in the structure.

# Records and Reports

The principal records and reports used in documenting concrete construction operations are the:

- Daily Diary,
- materials certification, sampling, and testing documents, and
- delivery tickets.

Your instructor or coach should be able to provide copies of examples of most of these records and reports.

## Daily Diary

The Daily Diary serves as both a record and a report of all key events that occur during the day. All Daily Diaries are the property of the Department and serve as the foundation of all construction project records, so they must be maintained neatly and legibly in ink. They are generally a summary of key events and information, but they must provide sufficient detail that other personnel can get an accurate picture of what happened each day.

The items recorded in the Daily Diary include:

- such routine information as:
  - identification of the project,
  - the type of work being done,
  - the location of the work,
  - the times work is started and stopped,
  - weather conditions,
  - special instructions or other communications sent or received, and
  - an inventory of the contractor's equipment and personnel resources being used on the work;
- information on any special events or problems encountered such as:
  - any official visitors to the project,
  - unusual conditions that may affect the work,
  - the times and causes of any delays,
  - important discussions with the Contractor and any specific instructions or orders given,
  - the rejection of any materials or work including the reasons for the rejection,
  - any changes, adjustments or corrective actions by the contractor, and
  - any other information that may be relevant to any potential disputes or claims; and

- summaries of the concrete construction work under way or completed during the day including the type and location of any:
  - structural excavation,
  - forms construction,
  - preparation of reinforcement,
  - concrete placement, finishing, and curing,
  - joint construction,
  - forms removal,
  - finishing, or
  - backfilling.
- field notes for concrete construction, used to record detailed technical information including calculations and diagrams used in such inspection activities as:
  - checking layout and grade controls,
  - determining structural excavation quantities,
  - checking foundation, forms, and reinforcement preparations,
  - verifying curing compound application rates,
  - calculating backfill quantities, and
  - measuring structural pay quantities.
- a "pour record" used to document each concrete pour in terms of:
  - the type and location of the structure;
  - identification of the delivery tickets for the mix used in the pour;
  - concrete and air temperatures prior to placement;
  - the quantities of mix placed, including the:
    - calculated volume, based on the plan dimensions of the structure, and
    - actual quantities of mix used, based on the delivery tickets for the loads of mix received (which includes wastage);
  - identification of any strength specimens prepared and other tests conducted; and
  - the date and time of the pour.

## Materials Certification Sampling and Testing

The inspector must control all materials used in the structure through a variety of documents including:

- Certificates of Compliance and Analysis,
- completed green tags or other evidence of pre-testing for curing compounds, sample tabulation cards for all samples collected at the site, and
- Concrete Test Reports for concrete slump, air content, and strength tests.

For additional information on certification, sampling and testing documentation, see the course **Field Sampling and Testing for Concrete Construction (**Course 201).

## Delivery Tickets

As each load of concrete mix is delivered to the project, the inspector must collect the delivery ticket that identifies the class of concrete, quantity, and batch time for the load. The inspector should note on the back of the delivery tickets:

- any water added and additional mixing at the site,
- the time discharged,
- the temperature of the mix prior to placement, and air temperature and
- the type and location of the structure in which the load is placed.

All delivery tickets for the day's operation must be submitted to the project office and maintained as part of the project records.